THE Petroleum Engineer

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• Drilling and Producing • Refining and Petrochemical • Oil and Gas Pipelining

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GENERAL

Elk Basin — The Cinderella Field A-37
R. J. Harvey and F. K. Krebill
Characteristics of Crude Oils From Big Horn Basin Fields A-52
W. J. Wenger and W. J. Lanum
Natural Gas for the Future E-2
Hines H. Baker
Managing the Modern Man E-16
E. G. Planty

Features

Course of Oil A-4
Advertisers' Index A-6
Highlights A-10
Petrolic Personalities A-14
Meetings A-16
Letters to the Editors A-18
Petroleum Profile A-62
Alexander Hamilton Bell
Women at Work E-23
Frances Oldham
Irene Gadelman
Marilyn Gerdom
General Personals E-28
Deaths E-41
Books E-42
The Petroleum Engineer's Continuous Tables E-45
(Installment No. 198)
Laugh With Barney E-60
Oil and Gas Trade News E-61
Trade Personals E-65
New Equipment E-71
Trade Literature E-76

DRILLING AND PRODUCING

Big Horn Basin — Wyoming and Montana B-21
M. M. Johnson
The Big Horn — Basin of Basins B-32
Sim H. Crews
Winter in Wyoming B-39
John R. Yoder and M. M. Johnson
Three Zones Produce in Oregon Basin B-42
B. W. Allen
Florida — U. S. Oil Frontier B-51
H. Gunter and R. O. Vernon
Emulsion Reduction in Big Horn Basin B-57
M. F. Westfall
A Study in Safety B-64
C. M. Harden and J. I. Morris
Deep Eocene Production Established B-73
William T. Rintoul
Artificial Formation Fracturing in Southern Oklahoma and North Central Texas B-75
W. L. Sallee and F. E. Rugg
Locating Zones of Fracture B-85
A. A. Stripling
California Brings in First New Tidelands Production B-94
William A. Moses
Production Maintenance B-97
Charles A. Breitung
All-Electric Drilling Rig Makes Debut B-100
Richard Sneddon
First Test Drilling in Angola B-107
Carlos A. Alves Pereira

Features

Editorial B-3
Digest of News and Comment B-6
What's Doing in Drilling B-110
Exploration Activities B-114
Running Tour With Men in the Industry B-116

REFINING AND PETROCHEMICAL

Development of Petroleum and Petrochemical Processing — Part 2 ..... C-5
Benjamin T. Brooks
Installation and Maintenance of Controlled Volume Pumps C-14
B. Bertolet
Synthesis of Petrochemicals—No. 7 ..... C-21
Everett E. Gilbert
Freedom Must Be Sold to Be Retained C-35
Arch L. Foster
Fuel Oil Upgraded to Diesel by Additive C-37
Eugene B. Brien
Analytical Methods
Microcombustion Train Aids Uniformity of Burning C-42
Determination of Fluoride in Refinery HF Alkylation Caustic Wash Solutions C-42
Technical Forum
Weight Volume Conversion Factors C-32
Comparison of H_2SO_4 and HF Alkylates C-32
HF Alkylation C-34
Ethylene Glycol Synthesis C-34
Plant Aids
Shut-in Pressure of Gas Well in Relation to Squared Pressures C-12
Positive Check Valve C-45
Pressure Controller Heat Coil C-45
Figuring Fuel Savings C-46

Features

Digest of News and Comment C-3
Refining and Petrochemical Personals C-47

OIL AND GAS PIPELINING

Surge Mysteries Nearing Solution D-5
Edwin J. Waller
Hot Tap Connection Design in High Pressure Pipe Lines — Part 2 ..... D-9
A. J. Del Buono, P. L. Vissat, F. S. G. Williams
Pipe Line Application of Wire and Cable D-13
R. C. Graham
Canadian Pipelining — 1953 Review D-19
Leslie Orr Rowland
"Backhoe Alley" is Rough Digging Country D-30
Buckeye Eastern Products Line Completed D-32
Eugene B. Brien
Adaptation of Semi-Automatic Welder to Magnetic Flux D-36
R. A. Hand
Pipe Line Procedures
Meter Run Production Increased by New Positioning Jig D-42
Interprovincial Loop Tie-in Time Cut to 27 Hours D-44
Visual Identification of Line Pipe D-46
Hans Schmoldt
Big Loop Program Scheduled on Interprovincial's Line D-65
Construction, Sales Boom Predicted Through 1956 for Pipe Lines, Utilities D-70

Features

Digest of News and Comment D-3
Pipe Line Pictorial D-40
Pipe Line Projects D-57
Pipe Line Developments D-53
Pipe Line Contractors D-62
Pipe Line Personals D-67

The PETROLEUM ENGINEER Publishing Company, 15th Floor, 1700 Commerce Street, DALLAS 1, TEXAS. T. J. CROWLEY, *President;* K. C. SCLATER, *Vice President and Executive Editor;* W. T. BRYAN, *General Manager and Treasurer.* **Editorial Staff**—FRANK H. LOVE, *Editor in Chief;* ERNESTINE ADAMS, *Managing Editor;* SIM H. CREWS, *Editor, Drilling and Producing;* ARCH L. FOSTER, *Editor, Refining and Petrochemical;* DEAN HALE, *Editor, Oil and Gas Pipelining;* RICHARD SNEDDON, *Editor, Pacific Coast,* 1106 B North Louise Street, Glendale 7, California. Phone Chapman 5-1951; EUGENE BRIEN, *Eastern Editor,* 52 Vanderbilt, New York 17, New York. Phone MUrray Hill 4-1880; MARY MORRIS LYMAN, *Assistant Editor.* **Advertising Staff**—T. J. CROWLEY, *President and Advertising Manager;* New York—JOE B. WOODS, 52 Vanderbilt Avenue, New York 17, New York. Phone MUrray Hill 4-1880; Chicago—E. V. PERKINS, 53 West Jackson Blvd., Chicago 4, Illinois. Phone HArrison 7-6883; Los Angeles—RICHARD P. McKEY, 465 East Union, Pasadena 1, California. Phone RY-1-8779; Dallas—ABBOTT SPARKS, 15th Floor, 1700 Commerce Street, Dallas 1. Phone STerling 4403; ABBOTT SPARKS, *Director of Promotion;* ED SEALEY, *Promotion Manager;* ROYAL COURTNEY, *Circulation Manager.*

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Shortage of Engineers Can Be Remedied

An acute shortage of college-trained engineers presents a serious problem to American industry. Approximately 30,000 engineering graduates are needed annually, according to the Engineering Manpower Commission, but in 1953 there were only 24,000 graduated. The prospect for 1954 is not even that bright, the estimate being for 19,000 graduates. Projecting the estimate into 1955 the downward trend continues—17,000 for that year.

Each year about 2,100,000 young people become of college age, and of this number some 210,000 who possess college ability do not go to college. There are several reasons for this. About a third simply are not interested in a college education, an equal number have plans that to them are of greater importance, and the other third lack the necessary funds. This last group of 70,000 contains many potential engineers who are lost to industry.

There is a practical solution to this problem. The solution is an increase in the number of scholarships provided by industry to worthy students. Cost of such scholarships vary in some degree with the university, but one leading educational institution gives a figure of $1500 a year as the cost of sponsoring an engineering student. It is further pointed out that when taxes are considered this figure will be materially reduced, seemingly a small enough expenditure to increase the supply of badly needed engineers.

The petroleum industry shares this shortage of engineers with all industry; if anything, it feels the condition more acutely than most because, being highly technical and mechanized, it needs a higher percentage of young engineers and scientists. To the credit of the petroleum industry it can be said that the number of scholarships made available each year by oil companies, product and equipment manufacturers, service organizations, etc., totals into the many hundreds. Still the shortage continues and many of these conscientious business concerns are reappraising the situation and increasing their appropriations for this purpose. It would be well if others did the same, and if those who are not now engaged in such a program give serious consideration to its importance.

If one cares to look beyond this matter as being a sound business policy, there are accruing benefits, such as good public relations, the fact that more educated people create greater markets because they require more of better products, and, finally, more trained personnel will enable the United States to maintain its position as a leader in technological developments.

Oklahoma to Revise Proration System

The State of Oklahoma, whose proration policy has drawn considerable criticism in recent months, is taking steps to remedy the situation and is to be commended for its prompt and forthright action. Accomplishment of the objective entails pursuit of two courses.

The Oklahoma Conservation Department, through its director, Walter T. Pound, has petitioned and received authority from the Oklahoma Corporation Commission to make a survey to determine the productive capacity of every oil well and lease in the state. Producers and pipe line companies alike are required to submit certified statements on the status of leases, non-compliance resulting in the severance of pipe line connections to leases. These data will serve as the basis for reclassifying all fields and devising a yardstick for fixing production allowable on a monthly basis.

The second step has been the appointment of a committee to revise present rules and regulations governing production. That the resulting decisions will be of an intelligent nature is attested by the caliber of the men who head the group. William T. Payne, president of Big Chief Drilling Company and Payne Petroleum, is chairman, and Roland V. Rodman, president of Anderson-Prichard Oil Corporation, vice chairman. They, plus the subcommittee members that have been appointed, can be safely entrusted with the task of presenting a plan that will be both workable and equitable to all concerned.

— Frank H. Love

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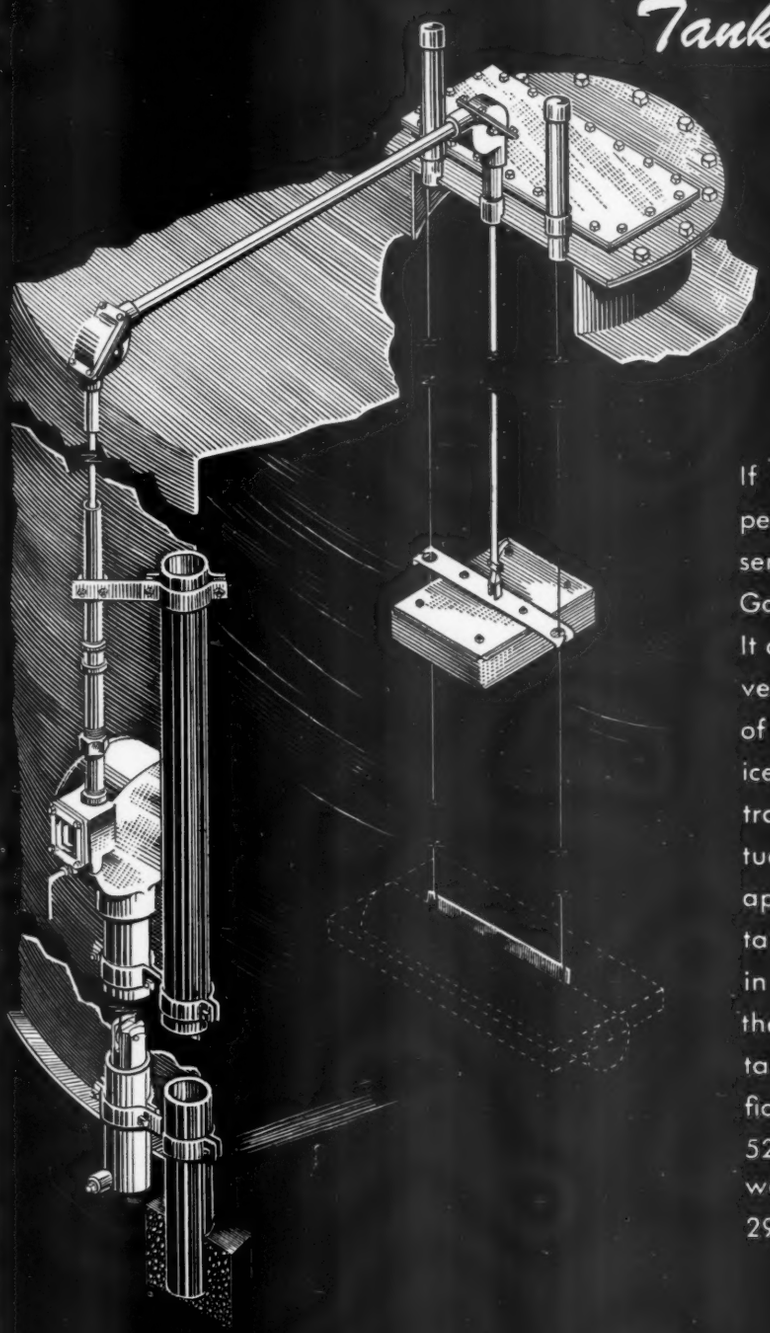

If you want to equip some of your petroleum storage tanks presently in service with S. & J. Automatic Tank Gages, there is no time like the present. It can be done at any time that is convenient to you, without the necessity of having to take the tank out of service. The S. & J. Automatic Gage illustrated here, is a high quality, float actuated gage designed for immediate application to five different types of tank construction. If you are interested in learning just how simple and quickly these gages can be installed on your tanks, write to any of the branch offices listed below for a copy of Bulletin 52-D which illustrates the five different ways of installing Gage Model ST-2935-S.

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HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Phillips Case Review

The Supreme Court reversed a recent decision, and announced it will review the so-called Phillips case. A lower court ruling had placed regulation of natural gas prices in the field in hands of Federal Power Commission, against the FPC's own decision, and Phillips, Texas, Oklahoma, and New Mexico appealed to the Supreme Court to review the decision. This the Court had refused to do when first asked, but recently announced it had changed its mind and would look the case over.

★ ★ ★

Oil at North Pole?

Salt domes with conditions favorable to accumulation of oil have been reported within 800 miles of the North Pole. Discovery was made by Canadian government geologists, who state the domes are similar to those leading to discovery of oil fields in Texas and Louisiana. Domes are on Ellef Ringnes Island, which is almost inaccessible.

★ ★ ★

Oil Search in Washington

Continental Oil Company is searching for oil in the state of Washington. The company is acquiring leases and exploratory rights in Grays Harbor area, and Grays Harbor County commissioners have granted the company right to drill core holes on county-owned property where oil and mineral rights have not been leased.

★ ★ ★

Fuel Oil Storage Down

A record drop in storage of fuel oils was reported recently when stocks were reduced by 6,213,000 bbl, API reported. Demand for fuel oil — heating oil — exceeded 16,000,000 bbl during one seven-day period, in which refineries produced 9,952,000 bbl. Kerosine stocks were down the same week to a total of 30,251,000 bbl compared with 28,628,000 bbl a year ago.

★ ★ ★

Gas Industry Expansion

Plant construction in the gas industry is expected to cost an average of $1 billion a year for the next four years, the American Gas Association reports. This includes $1.9 billion for transmission lines, $1.4 billion for new distribution facilities, and the rest for production, underground storage, and general plant expansion. An estimated $100,000,000 is planned for underground storage expansion.

★ ★ ★

Federal Oil Royalties

Federal oil royalties going to Wyoming reached a new high in 1953, when $5,804,117 from state production were distributed by the government to state institutions. The government holds 72 per cent of the mineral rights in Wyoming. Total royalties from output on Federal leases were $15,472,646 of which 52½ per cent went to a U.S. Bureau of Reclamation fund, and 1 per cent was disbursed to U. S. Treasury.

★ ★ ★

Record Stock Dividends

American stockholders received record dividends in 1953 — a total of $9,350,000,000. This compared with $8,875,000,000 the previous record, last year and $5,823,000,000 paid in 1929. Oil companies increased dividends, topped by Standard Oil of New Jersey who paid out $272,569,500.

★ ★ ★

Story of Texaco

Recently published is the story of The Texas Company titled "The Texaco Story — The First Fifty Years," by Marquis James. Company history is traced from its beginning as a small independent company at the time of the "Spindletop" gusher to its present role as a major integrated company.

★ ★ ★

Foreign Oil Money Up

Foreign petroleum investments by affiliates or subsidiaries of American oil companies totaled $4,291,000,000 at the end of 1952, Commerce Department reported. This marked a $900,000,000 increase since the end of 1950; most of it was in Canada and Latin America.

★ ★ ★

Conoco Stations Revamped

Continental Oil Company's service stations are getting a new look. Styled by Walter Teague, new stations feature a diamond pattern grid, formerly used only on Conoco motor oil can, so station can be identified at first glance. More use of glass allows operator to see pumps from all parts of station.

Import Solution Seen

Bright prospects for settling the import problem without legislation are being held out by Independent Petroleum Association of America. At a meeting of the group in Midland, Texas, recently President Eisenhower was praised for his statement in his State of the Union message to Congress that he would recommend "a sound program for safeguarding domestic production of critical and strategic metals and minerals."

★ ★ ★

Labor Merger Sought

Representatives of 10 independent labor unions in the oil industry met recently to discuss merging into one powerful group. Maynard M. Sands, president of Central States Petroleum Union, said bargaining by separate unions has been ineffective.

In Idaho recently members of CIO Oil and Chemical Workers International Union met to lay out plans for promoting a 36-hour work week and a guaranteed minimum annual wage.

★ ★ ★

LaFortune Closes PAD

Joseph A. LaFortune, deputy administrator for Petroleum Administration for Defense, said recently that as soon as he winds up PAD he will be back in Tulsa, Oklahoma. He said no plans had been made for the future, and that it might take until April to close entirely the doors on PAD. A skeleton force will remain in the Interior Department to build up another PAD in event of an emergency.

★ ★ ★

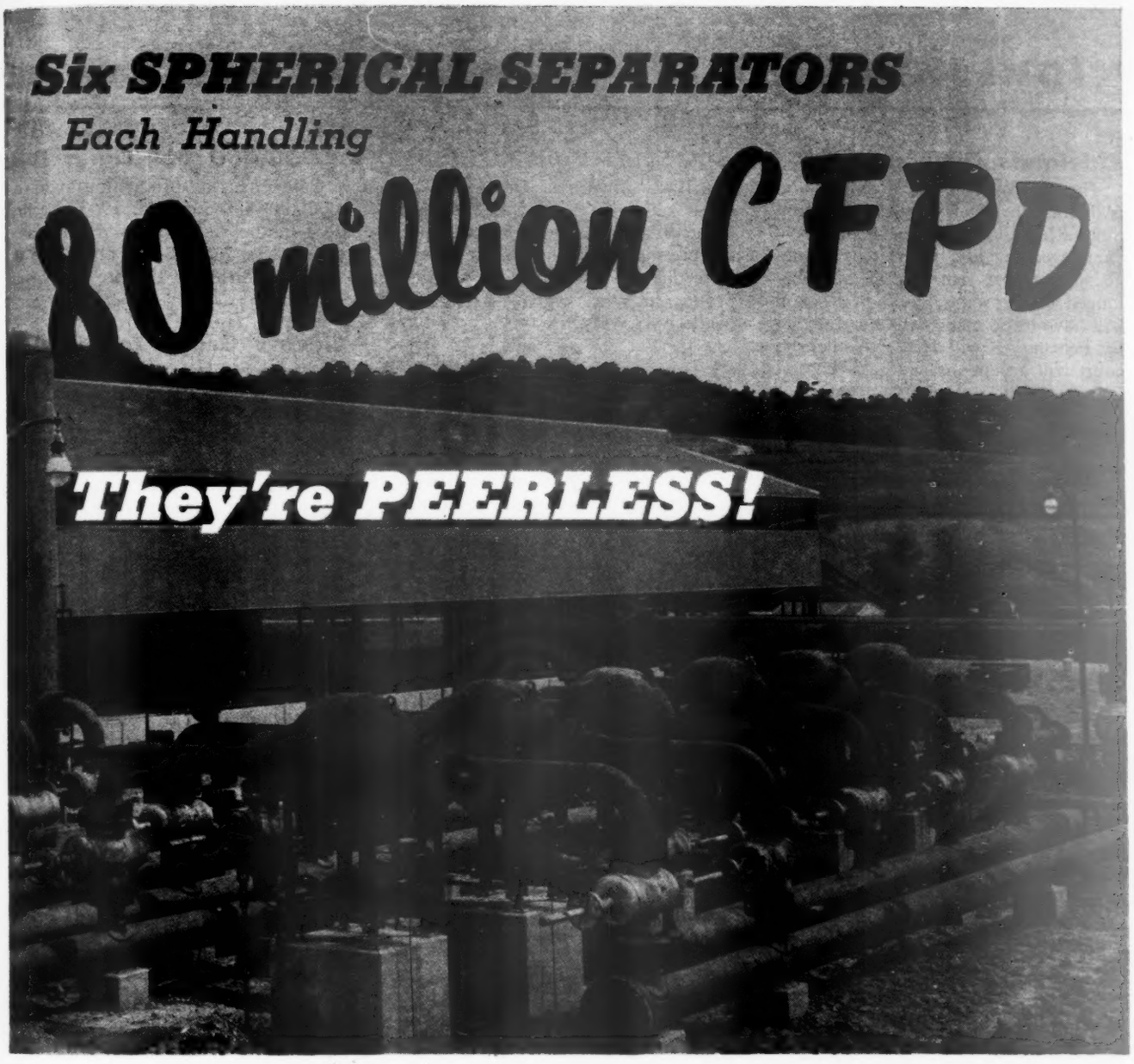
Oil Leading Mineral

Petroleum was Canada's No. 1 mineral in 1953. According to preliminary estimate of Bureau of Statistics, flow of crude oil was valued at $198,000,000, a gain of $55,000,000 from 1952. Oil even topped gold, which had led minerals in Canada for nearly 25 years.

★ ★ ★

U. S. Income Rate Up

National income in the third quarter of 1953 was set at an annual rate of approximately $308,000,000,000. This was a decrease from the annual rate set in the second quarter, but a 6 per cent increase over the $292,000,000,000 national income of 1952.



PEERLESS-SPECIALISTS in the SEPARATION of LIQUIDS and GASSES!

At a huge underground gas storage project in Pennsylvania, you'll find the SIX specially built PEERLESS SPHERICAL SEPARATORS, as pictured above. All compressed gas passes through these separators to prevent condensate from getting to the dehydration plant load and upsetting the schedule. These SIX PEERLESS SEPARATORS are good for 1,500 PSIG working pressure and are designed to pass 80 million CFPD each at 450 PSIG.

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HIGHLIGHTS . . . . . Digest of News and Comment

Tidelands Dilemma

The controversial tidelands question is facing the Supreme Court again. Since Rhode Island and Alabama have challenged legality of the Court's decision last year that the tidelands belonged to the states, another decision will have to be made. The hearing, set for February 1, will decide whether the court will accept the suit.

★ ★ ★

Coops Get Break

Tax situation of farmer groups owning refineries has been improved by Internal Revenue Service. Sales of by-products by these cooperative groups, not usable by farmers and farmer patrons, will not be included in deciding whether outside sales exceed statutory limitations of 15 per cent, IRS reported.

★ ★ ★

More Middle East Oil

A new shipment of crude oil hit western markets last month, from the Wafra field in the Neutral Zone between Kuwait and Saudi Arabia. Cargo is 100,000 bbl of crude for Pacific Western Oil, half owner of the concession. First shipment of crude from this field went to markets in Japan. Oil from Wafra concession, a new source of oil, is being developed by independents.

★ ★ ★

API Highway Policy

A statement of its policies on U. S. highways and care of same has been laid out in API's recent booklet titled "Highway Policy of American Petroleum Institute." Emphasized are 19 points, two of them are (1) revenues from state taxes on motor vehicle ownership should be dedicated to highway purposes by constitutional amendment, and (2) right to tax motor fuel and vehicle use should be reserved to states.

★ ★ ★

Gas-Turbine Auto

First gas-turbine automobile built and tested in the U. S. is General Motors' XP-21 "Firebird," which looks something like an ultra-modern space ship. Kerosine, burned in the chambers of the gas turbine, raises gas temperature to about 1500 F. Power for Firebird comes from power turbine, rather than thrust of exhaust gas through a tail cone like high velocity thrust that propels turbo-jet aircraft.

B-A Sales Volume High

British American Oil Company's sales volume in 1953 was 8 per cent higher than that for 1952, Ole Berg, Jr., president, reports. Higher earnings were due largely to higher production profits from the company's operations in the U. S.

★ ★ ★

Optimistic for Year Ahead

Sun Oil's president, Robert C. Dunlop, believes the coming year will be a good one for the oil industry. He thinks U. S. oil will do more business, giving its customers better values in terms of price, quality, and service. Demand will rise about 4 per cent, Dunlop predicts, but though this is lower than other years' increases, he says this does not constitute a recession. This levelling off of demand will intensify competition within the industry, he declared.

★ ★ ★

Average Price of House Brand Gasoline and Tax per Gallon

In 50 representative cities—on first of the month.

(Data gathered and compiled by The Texas Company)

Period	Service station price (Excluding tax)	Gasoline tax	Service station price (including tax)
1919	25.41c	.06c	25.47c
1920	29.74	.09	29.83
1921	26.11	.20	26.31
1922	24.82	.38	25.20
1923	21.06	.91	21.97
1924	19.46	1.48	20.94
1925	20.09	2.11	22.20
1926	20.97	2.41	23.38
1927	18.28	2.81	21.09
1928	17.90	3.04	20.94
1929	17.92	3.50	21.42
1930	16.16	3.79	19.95
1931	12.98	4.00	16.98
1932	13.30	4.63*	17.93
1933	12.41	5.41*	17.82
1934	13.64	5.21*	18.85
1935	13.55	5.29*	18.84
1936	14.10	5.35*	19.45
1937	14.59	5.40*	19.99
1938	14.07	5.44*	19.51
1939	13.31	5.44*	18.75
1940	12.75	5.66*	18.41
1941	13.30	5.93*	19.23
1942	13.96§	5.97*	20.43†
1943	14.12§	5.97*	20.53†
1944	14.19§	5.97*	20.59†
1945	14.22§	6.02*	20.50†
1946	14.69	6.08*	20.77
1947	16.93	6.18*	23.11
1948	19.54	6.34*	25.88
1949	20.27	6.52*	26.79
1950	20.08	6.68*	26.76
1951	20.31	6.84*	27.15
1952	20.24	7.32*	27.56
1953	21.01‡	7.39‡	28.39‡

* Including the federal tax on gasoline which became effective June 21, 1932 at 1c per gallon. On June 17, 1933, it was increased to 1½c per gallon; on January 1, 1934, decreased to 1c per gallon; on July 1, 1940, again increased to 1½c per gallon; on July 1, 1940, again increased to 1½c per gallon; and on November 1, 1951, increased to 2c per gallon.

§ Excludes OPA compensatory charges paid to Defense Supplies Corp., or its predecessors, to cover excess transportation costs as follows: 1942, .496c; 1943, .444c; 1944, .427c; 1945, .261c.

† Includes above special charges.

‡ Estimate.

1,000,000 Bbl Oil a Day

California's oil production averaged 1,000,000 bbl a day for 1953, the first time in the state's history. Estimated output was 365,513,000 bbl, some 6,064,000 bbl above the previous year.

★ ★ ★

Electric Group for Oil

Petroleum electric committee is being formed by American Institute of Electrical Engineers. Purpose is for spreading of information peculiar to oil and gas industry and assisting institute members in their work. W. H. Stueve will be chairman of the first conference, which will be held next September in Tulsa, under direction of the Tulsa AIEE section.

★ ★ ★

Oil Courses Offered

Would be oil men, or oil men desiring further technical training, are offered a well-rounded curriculum at Long Beach Public Schools and City College, Long Beach, California. Four courses began this month on different phases of the industry. Prevention and treatment of crude oil emulsion course begins next month. A two-year preparatory course in oil well drilling begins in September. This is an AAODC approved program, which qualifies student for junior college graduation and associate in arts degree.

★ ★ ★

Favor Federal Gas Tax

President Eisenhower recently proposed continuation of two-cent federal gasoline tax, and such proposal is gaining support in Congress. Some demands have been made, however, that entire amount be appropriated for federal-aid highway use. At present time tax is bringing in about twice as much as Congress sets aside for highways.

★ ★ ★

AIOC Wins Decision

Anglo-Iranian Oil Company received its first favorable decision in a Rome court since trouble with Britain over Iranian oil rights began. Claims of damage were denied an Italian company "Italpetroli", which had attempted to import Iranian oil into Italy. Damages were claimed on grounds it was forced to cancel plans to import oil because of action taken by AIOC. The company had warned the Italian firm against attempting the import, claiming exclusive rights to Iranian oil.

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PETROLIC PERSONALITIES

DICK SNEDDON

YE EDITOR FINALLY TAKES A HINT

It was our good fortune on a recent evening to run into our old friend Art Quackenboss, erstwhile marine genius of Union Oil Company, now crude purchasing agent, who was convoying a pair of estimable gentlemen from Warren Petroleum Corporation, to wit, Jim Reidy, a consequential member of the company's Tulsa staff, and Howard Montgomery, engineer in charge of the Warren gas operations at Houston. This convocation resulted in a most enlightening exchange of chit-chat that included politics, gin rummy, golf, poker, dominoes, and sundry other uncertain enterprises, and gave us an elegant opportunity to recall a most entertaining evening spent at the Quackenboss home some centuries ago.

The trio were mostly excited about business, however, and after getting several hints that would have dented the skull of a rhino, we finally caught on and departed leaving them to their machinations. It was a lovely seance, nonetheless, while it lasted and we were pleased no end to add a couple of right nice people to the roster of our acquaintances.

DISCOMFITING NEWS FOR MALE FISHERS

Now comes the fishing story to silence all further controversy and to show the mere piscatorial male once and for all how and where he stands, which is mighty shaky and nowhere. We have recently noised abroad the successively larger black marlin catches of Al Stevenson, Bert Devere, Ed Pellegrin, Howard Pyle, and Ted Sterling, which started at 114 lb more or less and in a series of exciting sweeps finally boosted the individual record to 360 lb. This latter figure made Ted Sterling the champion of Hawaii and in our innocence we thought it would be a long time before anyone would top him.

Then just a short while ago we learned from Howard Pyle that Liz Stark, the accomplished wife of Herb Stark, general superintendent for Honolulu Oil Corporation at Taft, had gone with her husband to Cabo Blanco, Peru, in early December. There, with total disregard of the discomfiture to which she was subjecting men fishers everywhere, she did willfully and maliciously catch a black marlin, weighing 1015 lb. This is the biggest fish of its kind ever caught by a woman anywhere and will no doubt be officially entered as world's record.

WORLD TRAVELERS CHECK IN

All of which reminds us that on the evening of the Los Angeles Petroleum Club annual meeting, Bill Thornbury, one of the west's more prosperous producers, and a consultant of note, introduced us to another pair of interesting people in the persons of Dr. Italo Veneziani of Bologna, Italy, and Jaime Botero, a widely traveled chap whose home was originally in Colombia but who is now working out of National Supply Company's New York office. Dr. Veneziani is a consulting engineer in Bologna. He was formerly field manager of British oil development in Iraq and for a couple of years was assisted in this considerable adventure by Bill Thornbury, who has also been around some. Dr. Veneziani has also managed Italian Government operations in Romania, is currently Italian representative for National Supply, and is a contract driller in his spare moments.

By way of relaxation, like most of his fellow countrymen, he sings at every opportunity, and in all respects is excellent company whether he is warbling an aria from a Verdi opera or cooking up another business deal. Jaime Botero started with National in 1945 in the engine plant at Springfield, Ohio, and then transferred to the export corporation. Since that time he has foraged around South America, Africa, Europe, and the Middle East, and at this precise moment is about to start all over again. When, at rare intervals, he has a little time for diversion, he devotes it to hunting and fishing, at both of which he is more than usually adept.

A HASTY SQUINT AT THE LOOK BOX

By way of last minute roundup, we might mention that Dave Day, Richfield veep, has been elected president of the Los Angeles Petroleum Club. Dave is ideally equipped for such a job, being a friendly sort of chap with the capacity to devote himself seriously to serious matters, or whoop it up with the boys, as the occasion warrants. He will be supported in the vice presidency by Wendell Jones the Bethlehem high tenor whose travels during the past few years have made the Marco Polo yarn sound more than a trifle inane.

The new directors were named to the board — Olen Lane, the Continental executive, S. F. Bowlby, Shell Oil vice president, and Ronald Swayze, vice president of General Petroleum Corporation — which adds more power to an already mighty powerful slate. On the same night, John Flanagan, the velvet haired Johnston Tester's export biggie, was elected prexy of the Los Angeles chapter Nomads. Johnny is the lad who once kept us from being pulled into the Pacific by an angry eight pound albacore. Needless to say we regard him very highly. He will be assisted by another good looking lad, Joe Schlarb of Chiksan.

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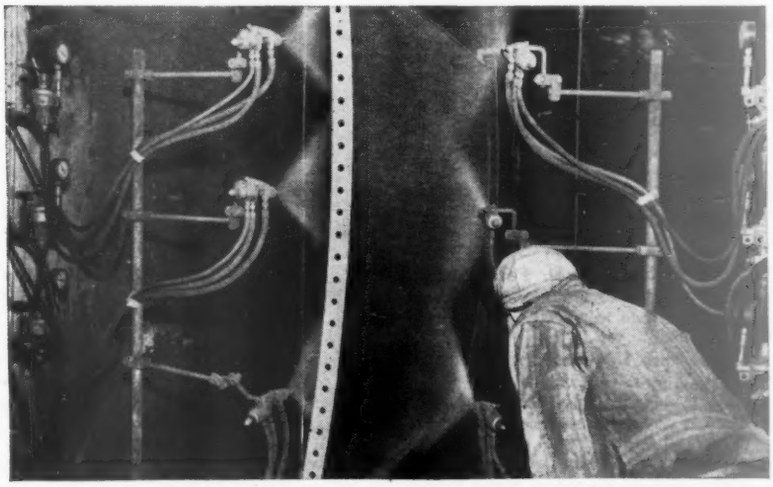

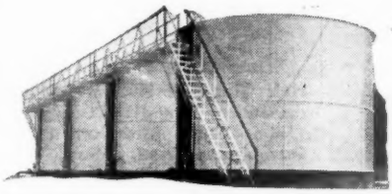

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MEETINGS ★

Feb. 11-12—**Western Petroleum Refiners Association,** regional meeting, Hotel Beaumont, Beaumont, Texas.

Feb. 15-17—**American Petroleum Institute, Lubrication Committee,** Sheraton-Cadillac Hotel, Detroit, Michigan.

Feb. 17-19—**National Association of Corrosion Engineers,** Tulsa Chapter, fifth annual Tulsa short course, Mayo Hotel.

Feb. 19-20—**National Society of Professional Engineers,** spring meeting, Hilton Hotel, Albuquerque, New Mexico.

Feb. 21-27—**National Engineers' Week,** featuring theme, "Engineering—Builder of Strong America."

Feb. 22—**American Association of Petroleum Geologists,** Rocky Mountain section, annual meeting, Albuquerque, New Mexico.

Feb. 23-24—**Packaging Institute (petroleum packaging committee),** Schroeder Hotel, Milwaukee, Wisconsin.

Feb. 24-25—**Wisconsin Petroleum Association,** Schroeder Hotel, Milwaukee, Wisconsin.

Feb. 26—**Natural Gasoline Association of America,** Permian Basin regional meeting, Lincoln Hotel, Odessa, Texas.

March 1-5—**American Society for Testing Materials,** spring meeting, Shoreham Hotel, Washington, D. C.

March 3-5—**American Petroleum Institute,** Division of Production, Southwestern District, Rice Hotel, Houston, Texas.

March 4-5—**American Gas Association, Transmission and Storage Conference,** Jung Hotel, New Orleans, Louisiana.

March 4-5—**American Society for Metals,** mid-winter meeting, Hotel Statler, Boston, Massachusetts.

March 8-10—**American Institute of Chemical Engineers,** Statler Hotel, Washington, D. C.

March 8-10—**Oil Industry Information Committee,** Houston, Texas.

March 15-19—**National Association of Corrosion Engineers,** annual meeting, Kansas City Municipal Auditorium, Kansas City, Missouri.

March 17-19—**American Petroleum Institute,** Division of Production, Mid-Continent District, Skirvin Hotel, Oklahoma City, Oklahoma.

March 24-April 1—**American Chemical Society,** Kansas City, Missouri.

March 25—**National Industrial Conference Board,** Ambassador Hotel, Los Angeles, California.

March 25—**Petroleum Accountants Society of Los Angeles,** Hotel Statler, Los Angeles, California.

March 25-26—**New England Gas Association,** Statler Hotel, Boston, Massachusetts.

March 27—**North Texas Oil and Gas Association,** annual meeting, Kemp Hotel, Wichita Falls, Texas.

March 29-31—**Western Petroleum Refiners Association,** annual meeting, Plaza Hotel, San Antonio, Texas.

April 4-6—**Texas Independent Producers and Royalty Owners Association,** Rice Hotel, Houston, Texas.

April 5-7—**American Society of Lubrication Engineers,** Netherland-Plaza Hotel, Cincinnati, Ohio.

April 6-8—**Petroleum Industry Electrical Association,** annual meeting, Dallas, Texas.

April 8-9—**American Petroleum Institute,** Division of Production, Rocky Mountain District, Townsend, Gladstone and Henning Hotels, Casper, Wyoming.

April 8-9—**Instrumentation Conference,** second annual, Louisiana Polytechnic Institute, Ruston, Louisiana.

April 12-15—**Society of Automotive Engineers,** national aeronautics meeting, Statler Hotel, New York, New York.

April 12-16—**American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists,** and **Society of Exploration Geophysicists,** annual meeting, St. Louis, Missouri.

April 13-15—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

April 14-16—**National Petroleum Association,** 51st semi-annual meeting, Cleveland Hotel, Cleveland, Ohio.

April 21-23—**Natural Gasoline Association of America,** annual convention, Baker Hotel, Dallas, Texas.

April 22—**Petroleum Accountants Society of Los Angeles,** Oakmont Country Club, Glendale, California.

April 26-28—**Southern Gas Association,** annual convention, Houston, Texas.

May 2-4—**Independent Petroleum Association of America,** midyear meeting, Cosmopolitan Hotel, Denver, Colorado.

May 3-5—**American Petroleum Institute,** Lubrication Committee, Skytop Lodge, Skytop, Pennsylvania.

May 3-5—**American Geophysical Union,** annual meeting, National Academy of Science, Washington, D. C.

May 3-7—**American Petroleum Institute,** Safety and Fire Protection Committees, midyear meeting, Chase-Park Plaza, St. Louis.

May 9-11—**Empire State Petroleum Association,** Roosevelt Hotel, New York, New York.

May 9-12—**Liquefied Petroleum Gas Association,** annual convention, Conrad Hilton Hotel, Chicago, Illinois.

May 10-12—**American Petroleum Institute,** Division of Transportation, Products Pipe Line Conference, Warwick Hotel Philadelphia, Pennsylvania.

May 10-13—**American Petroleum Institute,** Division of Refining, midyear meeting, Rice Hotel, Houston, Texas.

May 16-19—**American Institute of Chemical Engineers,** Conrad Hilton Hotel, Chicago, Illinois.

May 20-21—**National Industrial Conference Board,** 38th annual meeting, Waldorf-Astoria Hotel, New York, New York.

May 24-27—**University of Michigan, Symposium on Instrumentation,** University campus, Ann Arbor, Michigan.

May 28—**Petroleum Accountants Society of Los Angeles,** Hotel Statler, Los Angeles, California.

NOMADS TO MEET

New York N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First Monday of the Month. Secretary, M. W. Hiltpold.

May 31-June 5—**American Petroleum Institute, Division of Production,** midyear committee conference, St. Francis Hotel, San Francisco, California.

June 3-4—**Pennsylvania Grade Crude Oil Association,** 31st annual meeting. Hotel William Penn, Pittsburgh, Pennsylvania.

June 9-11—**Oil Industry Information Committee,** Edgewater Beach Hotel, Chicago.

June 13-18—**American Society for Testing Materials,** annual meeting and exhibits, Sherman Hotel, Chicago, Illinois.

June 17-19—**American Petroleum Institute,** Division of Production, Eastern District, Greenbriar Hotel, White Sulphur Springs, West Virginia.

June 20-23—**American Institute of Chemical Engineers and University of Michigan, Institute of Nuclear Energy,** University of Michigan, Ann Arbor, Michigan.

June 21-25—**American Institute of Electrical Engineers** (tentative date), combined summer and Pacific general meeting, San Francisco, California.

June 27-July 1—**Petroleum Equipment Suppliers Association,** Manor Richelieu, Murray Bay, Quebec, Canada.

Sept. 6-11—**American Chemical Society,** national meeting, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 8-10—**Oil Industry Information Committee,** Chicago, Illinois.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

Sept. 13-14—**Packaging Institute** (petroleum packaging committee), Philadelphia, Penna.

Sept. 13-16—**American Institute of Chemical Engineers,** Fairmont and Mark Hopkins Hotels, San Francisco, California.

Sept. 13-24—**Instrument Society of America,** First International Instrument Congress and Exposition and Ninth National Instrument Conference and Exhibit, Philadelphia, Pennsylvania.

Sept. 15-17—**National Petroleum Association,** 52nd annual meeting, Traymore Hotel, Atlantic City, New Jersey.

Sept. 16-17—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas Division, annual meeting, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 23-24—**National Industrial Conference Board,** Waldorf-Astoria Hotel, New York, New York.

Sept.———**Association of Desk and Derrick Clubs of North America,** annual convention, Banff Hotel, Calgary, Canada.

Oct. 4-6—**Texas Mid-Continent Oil and Gas Association,** annual meeting, San Antonio, Texas.

Oct. 7-8—**California Natural Gasoline Association,** 29th annual Fall meeting, Ambassador Hotel, Los Angeles, California.

Oct. 10-11—**American Association of Oil Well Drilling Contractors,** Biltmore Hotel, Los Angeles, California.

Oct. 11-14—**American Gas Association,** Atlantic City, New Jersey, hotel to be named.

Oct. 25-26—**Independent Petroleum Association of America,** annual meeting, Tulsa, Oklahoma.

Oct. 25-29—**American Institute of Electrical Engineers** (tentative date), Fall general meeting, Chicago, Illinois.

Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.

Nov. 1-2—**Independent Petroleum Association of America,** annual meeting, Shamrock Hotel, Houston, Texas.

Nov. 1-5—**National Metal Congress, National Metal Exposition,** Palmer House, Chicago, Illinois.

Nov. 4-5—**Society of Automotive Engineers,** national fuels and lubricants meeting, Mayo Hotel, Tulsa, Oklahoma.

Nov. 8-11—**American Petroleum Institute,** 34th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

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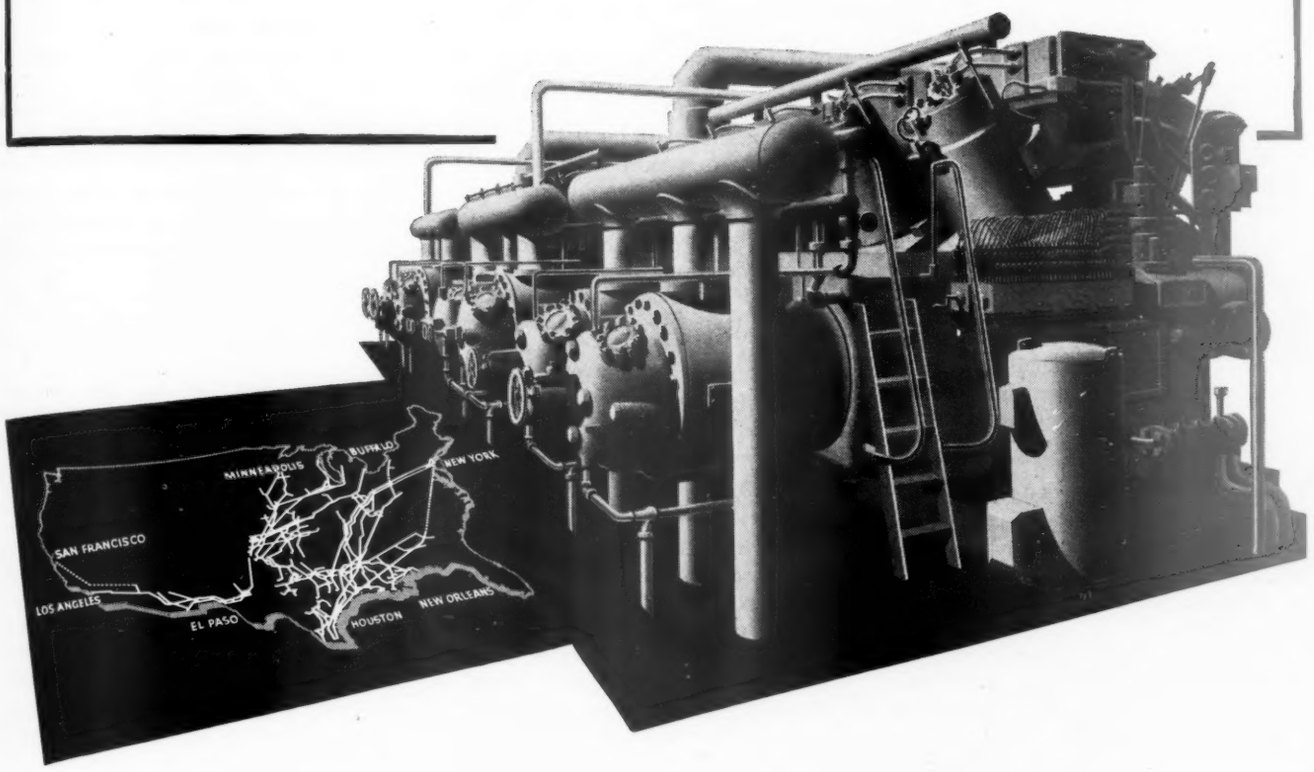

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LETTERS

★ ★ ★

"Burbank" of Oil Industry

To The Petroleum Engineer:

Just a note to congratulate you on the many excellent articles in your December issue.

That was a fine picture and article you had about my old partner, Wirt Franklin.

Both the technical articles you had on sand-fracing and its results, are very helpful.

I want to congratulate you on Clark Millison's "Petroleum Geology of Oklahoma" (B-93) and H. E. Staadt's article, "Sand, Important Factor in Successful Fracturing" (B-105).

Especially noteworthy is the detailed story by Richard B. Rutledge on the Velma field. I first visited Cruce and Velma and followed this uplift clear to Oil City in 1914. A year later, Sylvan Price, then connected with F. Julius Fohs, detailed these surface structures of Velma and Milroy. I've had many thousands of acres of leases on these structures, and regret that I did not acquire mineral interests, which would have held over until deeper drilling would have proved their worth.

The development and exploration of the great Velma oil field is a wonderful tribute to the vision and tenacity of my old friend, Bill Skelly, and his staff. Both The Texas Company and I dropped our holdings years ago, as did many others.

Bill Skelly is certainly the "Burbank" of the Petroleum Industry, having converted a "sour lemon" into one of the "sweetest of peaches."

Roy M. Johnson
Ardmore, Oklahoma

Remembering the Old Days

To The Petroleum Engineer:

The Petroleum Engineer has stopped arriving since July, and I miss it very much. I am one who has pioneered the Southwest, and can memorize the height of the oil industry activities, the great oil gushers, the many gasoline plants and refineries under construction in the days when highways were scarce. When the railroad trains called, "Coal Oil Johnny" left Tulsa for the great oil fields in Drumright and returned in the evening, working the oil fields over roads in mud axel deep. Business was good, the general construction engineer carried an order book in his hip pocket. He was privileged to hand out purchase orders for anything necessary to do the job, from a truck to a carload of valves. It really was interesting and my 35 years association with *the finest men on earth goes down in my book as the best days of my life.* All above was before *The Petroleum Engineer* was born.

Jos. Waldeck.

Numerous Requests Received

To The Petroleum Engineer:

We thank you for the prominence with which you displayed my article entitled "Oil Well Corrosion Control" in your April 1953 issue. I have received numerous requests for copies of the article, several from universities and a number from research laboratories associated with the petroleum industry. It also occurs to me that reprints of the article would be of considerable use to me as I offer the industry my services in the field of scale and corrosion control.

I would appreciate receiving some additional tear sheets if you have them available.

E. N. Frisius.
General Manager
Magna of Texas
Kilgore, Texas

Ammonia From Natural Gas

Editor's Note: (The following letters serve to clarify data and statistics as published in our April, 1953 Refining Progress Number, in which the production of ammonia from natural gas is compared to that produced from coal tar and other sources, and the information given is published here for the information of all concerned).

To The Petroleum Engineer:

The article "Petrochemicals Expanding 14 Per Cent Annually" by James H. Boyd and Claude A. Rackus in the April 1953 issue of *The Petroleum Engineer* was most interesting and informative.

In Table 14, "Production of Methane Petrochemicals," one could infer that the synthetic ammonia production listed was entirely from methane, whereas the production given was that obtained from all the raw materials used in the U. S. synthetic ammonia plants. Also in the discussion it is stated "In the United States today practically all synthetic ammonia is based on natural gas, whereas in 1940 it was based on coal and coke." While natural gas has made a spectacular growth in displacing coke as the major raw material, it still will not have "practically all the capacity" until the completion of the present program in 1955 at which time, according to my information, based on published and confidential sources, approximately 81 per cent of the capacity will be based on natural gas. This assumes that the du Pont plant at Belle and the Morgantown Ordnance plant will still be using coal and coke.

The following table gives my estimates for capacity based on the various raw materials. The "By-product hydrogen" heading includes capacity based on this raw material from petroleum refining and chemical processing as well as the caustic chlorine-electrolytic by-product hydrogen.

Estimated annual U. S. synthetic ammonia capacity and production in short tons NH_3

	Per cent capacity based on				
Year	Coke	By product H_2	Natural gas	Capacity	Production
1925	40	51	—	19,000	16,000
1930	93	7	—	197,000	142,000
1935	89	6	5	417,000	182,000
1940	86	6	8	460,000	435,000
1945	59	3	38	1,593,000	1,100,000
1950	55	3	42	1,940,000	1,566,000
1952	44	6	50	2,118,000	2,020,000
1955	12	7	81	3,485,000	

Capacities listed are for the end of the respective years which help explain part of the difference between capacity and production for those years in which new plants came on stream and only produced part of the year. Plants shut down because of economic conditions and strikes, capacity diverted to methanol production, and errors in estimation account for the remainder of the differences.

Although the information in the article on ammonia is essentially correct except in degree, I am forwarding my analysis in case it is of interest to you or either of the authors.

F. D. Kuenzly.
Plant Manager
Shell Chemical Corporation
Ventura, Calif.

To The Petroleum Engineer:

With reference to F. D. Kuenzly's letter on our "Petrochemicals Expanding 14 Per Cent Annually" in the April 1953 issue, we are pleased to have his comments.

At the time of our study, our estimate of the portion of synthetic ammonia capacity based on natural gas and petroleum refinery gas raw materials amounted to approximately 70 per

cent of the total capacity. This includes coke to gas plant conversions scheduled for completion in the first half of 1953. The trend is toward even greater use of gases for ammonia. We should have said that synthetic ammonia is dominantly based on petroleum gases rather than "practically all the synthetic ammonia is based on natural gas."

Further, our classification of ammonia as a "methane petrochemical" in Table 14 is a "convenient grouping of chemicals based dominantly but not exclusively on methane" and such a classification is, of course, arbitrary. However, others also have found this classification convenient.

James H. Boyd, Consultant.
C. A. Rackus, Co-Author
General Aniline Works
New York 14, New York

Exclusive SOD Licensee

To The Petroleum Engineer:

I would like to set the record straight on the item on page C-18 of the October issue of *The Petroleum Engineer* discussing the recently-signed agreement between Standard Oil Development Company and National Research Corporation. Contrary to the impression created by your treatment of our announcement, National Research is not a licensor for an SOD extraction process; rather, we are the exclusive SOD licensee authorized to design, build, and sell the new liquid-liquid extractor developed for SOD by Professor M. R. Fenske of Penn State College. Manufacture and sale of the extractor is handled by the Equipment Division, National Research Corporation, 70 Memorial Drive, Cambridge 42, Massachusetts.

Gordon Kiddoo.
Director
Development Department
National Research Corporation

Pipe Line Coverage Praised

To The Petroleum Engineer:

We wish to thank you for the excellent article on the Trans Mountain Oil Pipe Line project, in your November issue of *The Petroleum Engineer.*

Your coverage of the completion of the construction and the opening of the line for operation was greatly appreciated.

H. H. Anderson.
Vice President and General Manager
Trans Mountain Oil Pipe Line
Vancouver, B. C.

Drilling With Ultrasonic Sound

To The Petroleum Engineer

In discussion with one of our engineers, I was informed that an article dealing with the possibility of oil well drilling with high frequency or ultrasonic sound was published in one of the petroleum industry periodicals approximately six months to a year ago.

I have been unable to locate this article and would indeed appreciate your assistance in this connection.

We take the opportunity at this time to congratulate you and your staff for the excellence of your publication, which is not only informative but of real aid to us in our varied oil industry activities.

Thanking you for your interest in this regard, and awaiting your communication with interest, we are

George J. Kruse
Sales Manager
Eastman International Co.

Interested in Oklahoma

To the Petroleum Engineer:

It is of interest to me that you are including several papers concerning the geological prospects in the state of Oklahoma for commercial oil and/or gas production. (December, 1953, issue). I am particularly interested in the prospects of shallow productive zones above 3000 ft in Oklahoma.

I am also interested in the procedures of restrictions concerning proration of oil and gas wells there.

Melvin X. Hobby
Texas Gas Corporation
Houston, Texas

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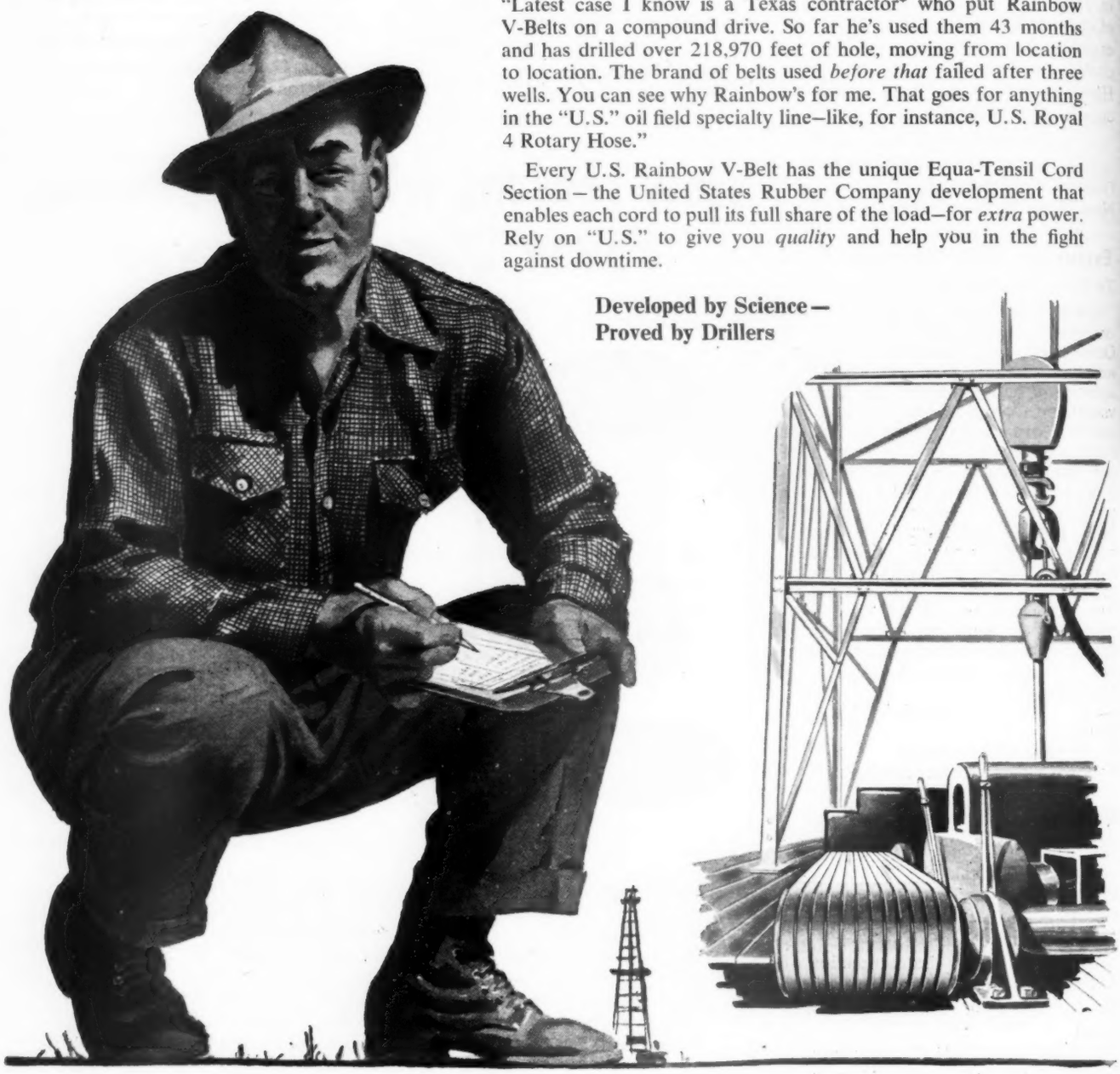

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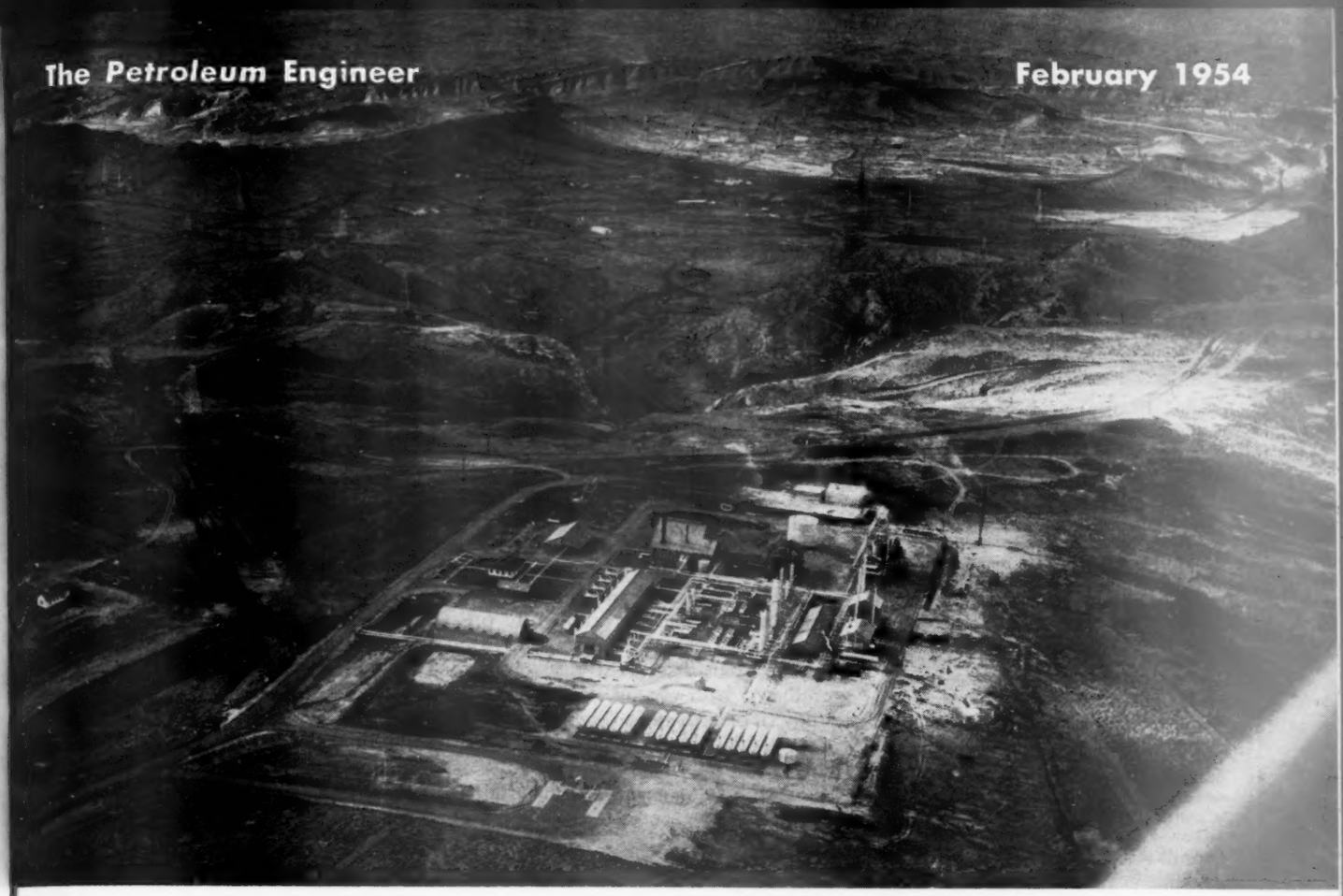


Elk basin unit plant with a portion of field in background.

P 530.

ELK BASIN — THE *Cinderella* FIELD

Unitization transformed this field into a shining model of conservation — Sour gas is turned into LPG and sulfur — Nitrogen from the process is used to maintain pressure

R. J. HARVEY and F. K. KREBILL

THE Elk Basin field is in the north-central portion of the Big Horn Basin in Carbon County, Montana and Park County, Wyoming. The field is approximately 50 miles east of Yellowstone Park and 200 miles north of Casper, Wyoming. The field lies on an elongated asymmetrical anticline with the major axis trending northwest-southeast. Highly eroded outcroppings in the field give evidence to the structural features of the anticline.

In 1915 the discovery well was completed in the Frontier sand. Light green 43 deg API gravity oil was found in two sands in the Frontier formation at depths ranging from 1100 to 1700 ft. The Second Frontier has been the most prolific and has produced 90 per cent of the Frontier oil recovered to date. This sand with an average thickness of 50 ft has a proved productive area in excess of 400 acres. The Second Frontier has been subjected to a low pressure gas drive operation for the past 27 years and the formation is now in its latter stages of depletion under present operating practices.

EXCLUSIVE

Gas reserves were discovered in the Dakota sand in 1922. This formation which is approximately 45 ft thick lies at an average depth of 2500 ft. The reservoir has a proven productive area of 1080 acres. The Dakota reserves are nearly depleted and the reservoir is now used as a storage facility by a commercial gas company.

The Embar-Tensleep oil reserve was discovered in 1942. This formation lies at an average depth of 4900 ft and has

XUM

The Authors

R. J. Harvey

F. K. Krebill

Robert J. Harvey is plant engineer for Stanolind Oil and Gas Company at the Elk Basin plant after being a process engineer in the Tulsa general office from 1948 to 1950, and again in 1952. After graduating from the State College of Washington in 1943 and serving three years in the Army, he attended the University of Tulsa, receiving a MS degree in petroleum refinery engineering in 1948. The Korean War accounts for the gap in his process design duties.

F. K. Krebill, a native of Colorado, received his BS degree from Colorado A&M in 1948. In that year he began his employment with Stanolind as a junior petroleum engineer in the Elk Basin field. Late in 1949 he was transferred to the Rangely field. He is now a petroleum engineer in the reservoir section of Stanolind's district office in Cody, Wyoming where he has been for the past 18 months.

a proved productive area in excess of 6000 acres. The reservoir consists of a 210-ft section of Tensleep sandstone of Pennsylvanian age overlain by a 40-ft section of Embar Dolomite of Permian age. The structure at the Embar-Tensleep depth has more than 2000 ft of oil filled closure with strata dipping an average of 21 deg on the west flank and an average of 45 deg on the east flank. The reservoir oil is a high sulfur content crude averaging 30 deg API gravity. The oil was undersaturated with gas at original reservoir pressure. At the time of discovery, the Embar-Tensleep solution gas had the highest hydrogen sulfide content of any gas produced in the Rocky Mountain region. At the present time a pressure maintenance program is in operation in this reservoir. An inert gas is generated from the produced gas and is injected into the crest of the structure.

In 1946 the Madison limestone oil reserve was discovered. This formation of Mississippian age has a proved productive area in excess of 5000 acres. The formation averages 920 ft in thickness and lies at an average depth of 5150 ft. The Madison crude is also a high sulfur content oil with an API gravity of 28 deg. The crude was undersaturated at the time of discovery. An active water drive is the producing mechanism in the Madison reservoir. The sour solution gas is processed in the gas plant.

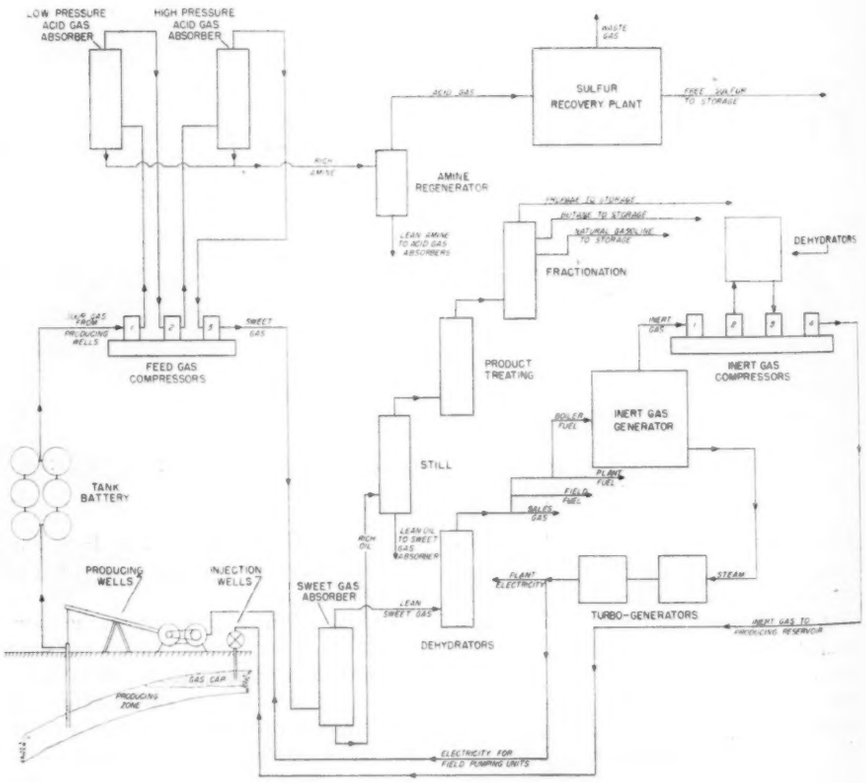
Embar-Tensleep Unitization and Pressure Maintenance

The Embar-Tensleep producing and pressure maintenance program is one of the most interesting and unique operations in the Big Horn Basin. The operation is unique in several respects. It is one of the first projects designed to recover elemental sulfur from oil field gases, and it is one of the first projects to use nitrogen successfully for maintaining reservoir pressure.

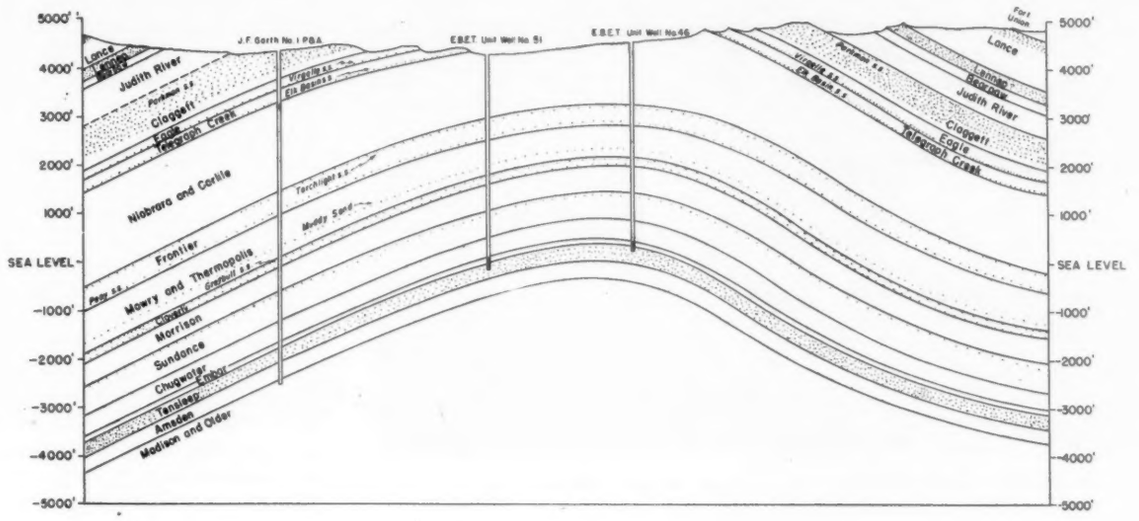
Soon after the size and extent of the Embar-Tensleep reservoir was defined, the various field operators initiated an engineering study to determine the most efficient method of producing the field. Need for an engineering study was highlighted by the formation of a secondary gas-cap, apparent lack of sufficient water drive to maintain reservoir pressure, and the problem of protecting personnel and equipment from the injurious effects of the sour gas produced with the oil. Results of the study indicated that high producing rates could be maintained and recovery efficiency improved considerably if production of free gas were curtailed and if reservoir pressure were maintained.

The easiest way to curtail free gas production and maintain reservoir pressure, to the satisfaction of all operators, was to unitize the entire reservoir. Reservoir energy could be conserved by shutting-in high gas-oil ratio wells and redistributing withdrawals to those areas of the field that were not in the secondary gas-cap. Also, a workable repressuring program could be initiated to maintain the field's producing capacity at a high level. In addition, unitization would result in higher operating efficiency due to consolidation of field facilities.

Two types of repressuring programs were studied: (1) water injection around the edge of the field, and (2) gas injection into the crest of the structure. Water injection plans were abandoned because of the expense of drilling injection wells and developing an adequate water supply. The gas injection scheme was also threatened by lack of an adequate gas supply. The Elk Basin field did not have the necessary amount of hydrocarbon gas needed for repressuring because sweetening and removing the LPG from the Embar-Tensleep solution gas reduced the volume too greatly. It was not deemed advisable to inject the sour gas without sweetening because of its corrosive effect on equipment. All other known sources of hydrocarbon gas within an economic dis-



Elk Basin repressuring plant flow diagram.



GEOLOGIC CROSS SECTION OF ELK BASIN FIELD

SCALE

tance were committed to other uses.

Because of insufficient quantities of hydrocarbon gas, generation of an inert gas was considered. Studies indicated that the volume of sweetened solution gas obtainable in Elk Basin could be expanded approximately nine and one-half times by using it to generate an inert gas. By generation of inert gas, adequate volumes of gas for repressuring were assured.

The results of the engineering study were presented to the operators in September 1944. After a period of negotiation, all formations below the top of the Embar formation were unitized effective May, 1946. Stanolind Oil and Gas was appointed unit operator. Other major working interest owners include Carter Oil, Ohio Oil, Continental Oil, Argo Oil, Sinclair Oil and Gas, Phillips Petroleum, and R. S. Shannon.

After unitization became effective, Stanolind Oil and Gas Company, as unit operator, took over the operation of all unitized properties. All of the field facilities were consolidated and numerous duplications were eliminated. Eight consolidated tank batteries took the place of forty-six batteries that existed prior to unitization. Equipment was standardized as much as possible so that servicing and maintenance work could be effected more efficiently. Wasteful gas production was halted and reservoir energy was conserved by shutting in high gas-oil ratio wells in the gas-cap area.

Parallel with the consolidation of field facilities, plans for the construction of the gas plant were completed. Gas gathering lines were laid to all tank batteries and high pressure injection lines were laid to eight crestal wells, four in the north dome and four in the south dome. The plant was completed and began processing gas in March, 1949. With the use of natural gas the injection system and injection wells were tested through the summer, and by September, 1949, full scale nitrogen injection operations were inaugurated.

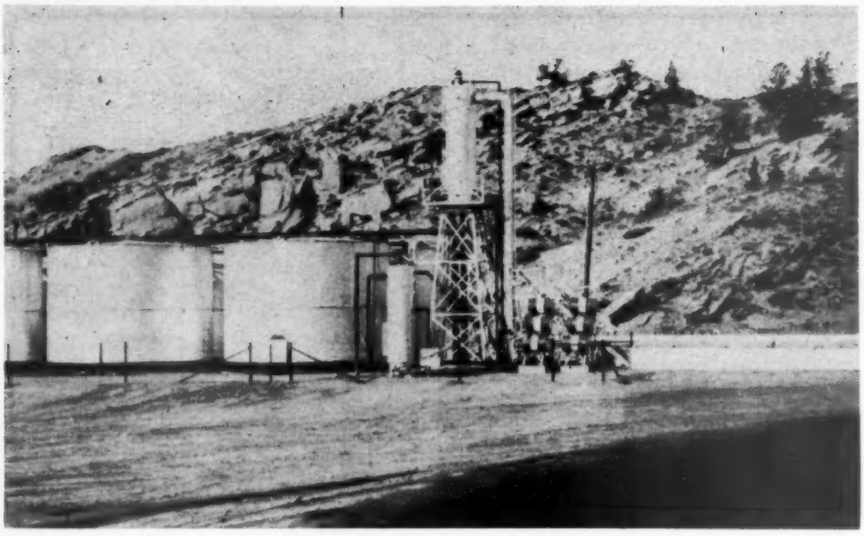
The completion of the gas plant allowed field operations to be fully integrated. Gas produced with the oil is piped to the gas plant where the deadly hydrogen sulfide is removed and converted to sulfur. Then, other salable products such as propane, butane, and casinghead gasoline are stripped from the sweetened gas before it is burned in a steam generating boiler. Steam from the boiler is used for plant processing and generating electricity. Flue gases from the boiler stacks constitute the inert gas used for injection. A small amount of sweetened gas is sold.

Sampling boxes on side of tank eliminates thiefing tanks through open hatches and exposing gager to sour gas.

Pressure Maintenance Plant

The Elk Basin pressure maintenance plant is characterized by the successful application of an idea. This idea was to produce a controlled furnace atmosphere and subsequently compress this generated atmosphere to a pressure sufficient for field injection purposes. The idea of producing a controlled atmosphere was not novel, as it had been well known for years in the metallurgical industries. The idea had no prior, however, successful, practical application in secondary recovery of crude petroleum. The most important factor in inert gas generation and compression is close control of potential corrosive agents.

The decision to employ inert gas as an injection medium into the gas cap of the Embar-Tensleep reservoir in turn dictated to a large degree the type of plant to be installed. This decision resulted from the fact that the program demanded more gas than was available from the field or than could be purchased with an economical transmission distance. From MER considerations, the design plant intake rate was



Elevated separators allow more complete separation of oil and solution gas.

set at 12,000,000 std cu ft per day, and 14,000,000 std cu ft per day as the desired inert gas injection rate. Theoretically, the perfect combustion of a paraffin hydrocarbon type fuel of 1100 Btu per cuic foot gross heating value will yield about 9.5 volumes of dry flue gas per volume of fuel burned. From the volume of inert gas desired, it was readily apparent that generation of this gas would yield high pressure and temperature steam in sufficient quantity to satisfy most of the process requirements. Specifically, steam could be used to maintain rich oil still temperatures and drive turbines for economical electrical power generation for plant and field needs, i.e. motor driven process pumps, fans for air cooling on services down to about 140 F, and motor driven well pumping units.

The high hydrogen sulfide content, about 16.5 per cent, and the high GPM content, of propane and heavier components, together with a large regional demand for propane and an attractive market for sulfur dictated that facilities for high propane recovery, removal of hydrogen sulfide, and recovery of sulfur be installed. The succeeding paragraphs will present a more detailed description of the process facilities.

The inert gas generator is a standard water-tube, gas-fired type boiler surrounded by a pressure tight casing and equipped with means for close combustion control and flue gas recirculation. As mentioned before, control of potential corrosive agents, especially oxygen, is the critical factor in this operation. Essentially a neutral furnace atmosphere, i.e., not over 0.05 per cent oxygen and not more than 0.5 per cent carbon monoxide and free hydrogen is produced by operation closely approaching theoretical combustion.

Control of excess oxygen is obtained primarily by a combustible controller maintaining the proper air to fuel ratio in that a maximum of 0.5 per cent combustibles in the flue gas is maintained. Secondary control of oxygen is obtained by means of the pressure-tight steel casing preventing air infiltration. This casing operates at approximately two inches water differential above the firebox pressure, the pressure being maintained by recirculating cooled flue gas to the casing. The proper adjustment of the induced-type gas burners is important in maintaining a low excess oxygen content. An instrument for indicating the oxygen content was included in the installation.

Formation of nitric oxides is minimized by lowering flame temperatures about 1000 F through dilution of the combustion air by means of recirculated flue gas. The lower boiler wall temperatures resulting from recirculating flue gas to the pressure-tight casing aids in reducing flame temperatures.

In the design of such installations, consideration should be given to the location of the combustion air intake to prevent outside contamination, i.e. sulfur plant stack gas. In addition, trace quantities of hydrogen sulfide in the fuel will result in the appearance of traces of sulfur dioxide in the flue gas.

The flue gas from the boiler stack is delivered after cooling to the compression system by means of a turbine-driven gas-booster blower. A conventional, four stage compression system is utilized to deliver the gas to the field at 1500 psig. The gas is dehydrated after the second stage of compression by means of activated alumina, the control dew point being minus 20 F at 1500 psig. Condensate corrosion is minimized by means of aqua ammonia injection to maintain the ph of the water removed from the system between 6.5 and 7.0.

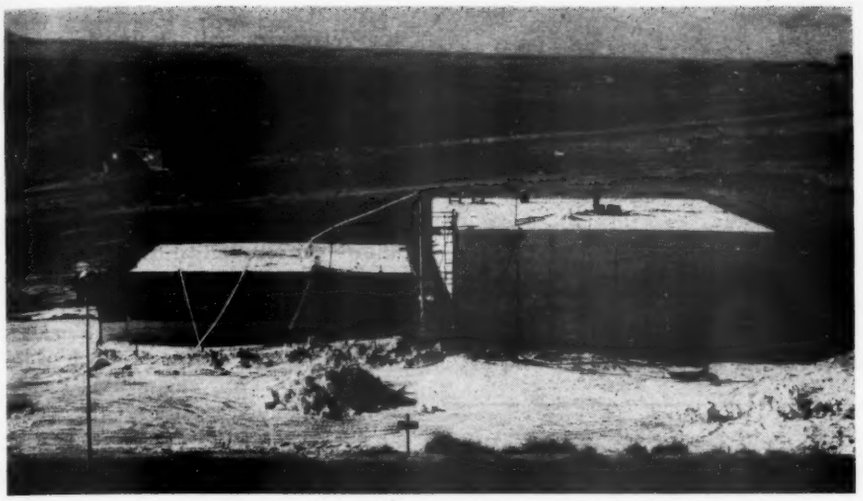
Feed gas compression facilities include three stages of compression to boost the plant inlet gas from 0.5 psig. to 540 psig, a suction and discharge scrubber on each stage, and an aftercooler on the discharge of each stage. Compression condensate from the first and second stage discharge scrubbers is routed to a drips surge drum operating at 6 psig. Vapors from the surge drum are recycled back to the inlet scrubber. A drips still is provided for endpoint and color control of the liquid from the drips surge drum, if necessary. Removal of hydrogen sulfide from this stabilized compression condensate is effected in a liquid amine contactor operating at 175 psig. Condensate from the third stage discharge scrubber, together with sweet stabilized condensate, is combined with the rich oil from the main absorber.

In sour gas plants, the proper design and operation of the acid gas removal system, i.e. hydrogen sulfide and carbon dioxide, is of paramount importance. Continuous removal of acid gas and regeneration of the 10 per cent to 20 per cent monoethanolamine solution is accomplished by employing two contacting columns operating at low temperatures, and a tower operating at high temperature and low pressure for the regeneration of the amine solution. Gas from the first stage discharge scrubber is routed to the low pressure contactor and gas from the second stage discharge scrubber to the high pressure contactor for final removal of hydrogen sulfide.

To reduce utility requirements, the acid gas removal system was designed with a split flow arrangement. The total rich amine flow is routed to the top of the amine regenerator, with 250 gpm of semi-lean solution being withdrawn from the center of the column and 250 gpm of lean-amine solution from the bottom of the column. The semi-lean amine solution is routed to the low pressure contactor, as well as one-half of the lean solution. The remainder of the lean solution is routed to the top of the high pressure contactor to effect removal of about 100 grains of hydrogen sulfide per 100 std cu ft of gas. The rich amine flow from the bottom of the high pressure contactor passes to the top of the low pressure contactor with the semi-lean amine stream.

Removal of iron sulfide sludge is accomplished by filtering the rich amine stream, employing diatomaceous earth as the filter medium. Soluble, but nonvolatile, impurities in the solution are removed by distillation in the amine reclaimer.

A one-still system is utilized with the rich oil from the main absorber, together with the compression condensate from the liquid amine contactor and third stage discharge scrubber, be-



Sulfur is stored in solid blocks which measure 50 ft by 50 ft by 18 ft high and weigh 3500 to 3700 tons.

ing substantially deethanized in a fractionating absorber prior to its entry to the rich oil still. The system was designed to absorb about 90 per cent of the propane in the main absorber and achieve about 80 per cent retention of propane in the fractionating absorber. A constant reflux control is employed in the rich oil still allowing the top temperature to vary according to changes in composition. The still net overhead or fractionator feed stream passes to a caustic pretreater where residual traces of hydrogen sulfide and a portion of the mercaptans are removed. Removal of the remaining mercaptans is accomplished in a regenerative caustic unit.

Instead of the conventional, cascade fractionating system, the fractionator feed stream, after caustic treatment, is pumped to the depropanizer. The depropanizer net overhead comprises the feed to the deethanizer, and the depropanizer bottoms the feed to the debutanizer.

Dry propane product is produced from the bottom of the deethanizer and sent to storage. The deethanizer net overhead is normally routed to the residue gas system, but can be recycled through the main absorber.

Normal operation of the debutanizer consists of making a butane product overhead and a 14# RVP natural gasoline off the bottom. Copper chloride treaters convert the mercaptans in the natural gasoline to less objectionable disulfides prior to its entry into storage.

All storage tanks are of the conventional horizontal cylindrical type with enough capacity for ten days' production.

Sulfur Plant

The sulfur-recovery operation is a modified Claus process converting the acid gas from the amine treating unit to elemental sulfur. The approximate composition of the acid gas is 74 per cent hydrogen sulfide, 21 per cent carbon dioxide, 2 per cent hydrocarbons and inerts, and 3 per cent water vapor.

One-third of the total acid gas stream is burned in a special boiler liberating heat for the generation of 200 psig steam. The furnace effluent, after mixing with the other two-thirds of the acid gas stream, passes to a reactor filled with a bauxite catalyst, where the hydrogen sulfide and sulfur dioxide react to form elemental sulfur and water vapor. The exit gas from the reactor passes into a condenser-separator where the sulfur vapor is condensed and the gas mixture temperature lowered to about 300 F. About 75 per cent of the potential product sulfur is formed in the No. 1 reactor and condensed in the No. 1 condenser-separator. The remaining gas from No. 1 condenser-separator is reheated in an acid-gas fired, inline burner, and passes to a second reactor and condenser-separator where additional sulfur is produced. Normal routine control of the air to acid gas ratio is based on maintaining the hydrogen sulfide-sulfur dioxide ratio in the stack gas between 1.5 and 3.0.

Under design conditions, the plant processes approximately 2,900,000 std cu ft per day of acid gas and produces approximately 80 long tons of sulfur per day. Liquid sulfur is transferred to a storage area where it is solidified into blocks of about 3600 long tons. These blocks are then broken up, by using dynamite, and hauled by truck, 17 miles, to a crusher where it is loaded on standard railroad cars.

Reservoir Performance

Effects of unitization and nitrogen injection on the Embar-Tensleep reservoir performance are very evident. Prior to unitization, reservoir pressure was falling rapidly even though the producing rate was only in the order of 10,000 bbl of oil per day. With selective production following unitization, the rate of pressure decline was reduced even though the producing rate was increased by 50 per cent. Leveling of the pressure decline curve can be expected after the bottom hole pressure reaches the bubble point, but in this instance pressure had fallen to the bubble point in only a small area at the crest of the structure. Therefore the leveling of the pressure decline between 1946 and 1949 has to be attributed primarily to the shutting-in of high gas-oil ratio wells, and selectively producing low gas-oil wells downstructure.

Since commencement of nitrogen injection the pressure trend has been reversed. Bottom hole pressure has increased approximately 100 psi even though oil producing rates have been stepped up to approximately 19,000

Pacific Coast's First Large Water Flooding Plan Underway

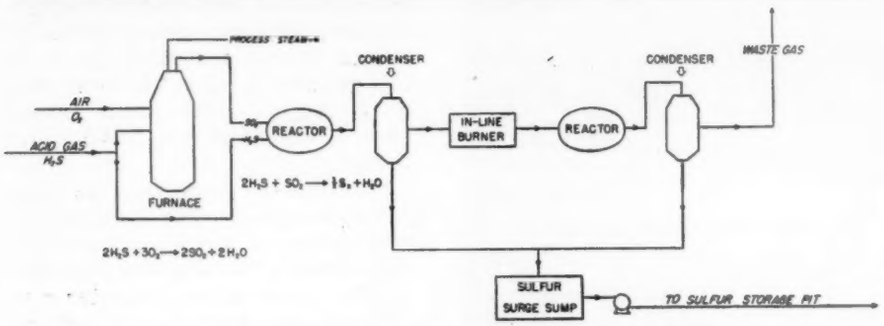
The first large scale cooperative water flooding program ever to be operated in California has begun at Dominguez oil field in Los Angeles County by Union Oil Company, Shell Oil Company and the Dominguez Oil Field Company. The program is expected to add substantially to the known crude oil reserves of the field.

This secondary oil recovery operation in which water is used to flush the oil sands is the direct result of successful pilot tests made at Dominguez by Union Oil, plus engineering studies and appraisals by the three companies during the past two years.

Approximately $1,400,000 will be spent for drilling and well repair operations, plus an additional $350,000 for water treating and injection facilities. All of the investment costs and subsequent operating expenses will be borne by the three.

Plans call for the cooperative water flood of the "First East Central Fault Block embracing the Hellman and Reyes properties," according to H. D. Aggers, manager of secondary recovery operations for Union Oil.

Although water flooding has been highly successful and is widely practiced in other oil producing areas, this operation will be the first large scale cooperative "flood" to be conducted on the Pacific Coast.



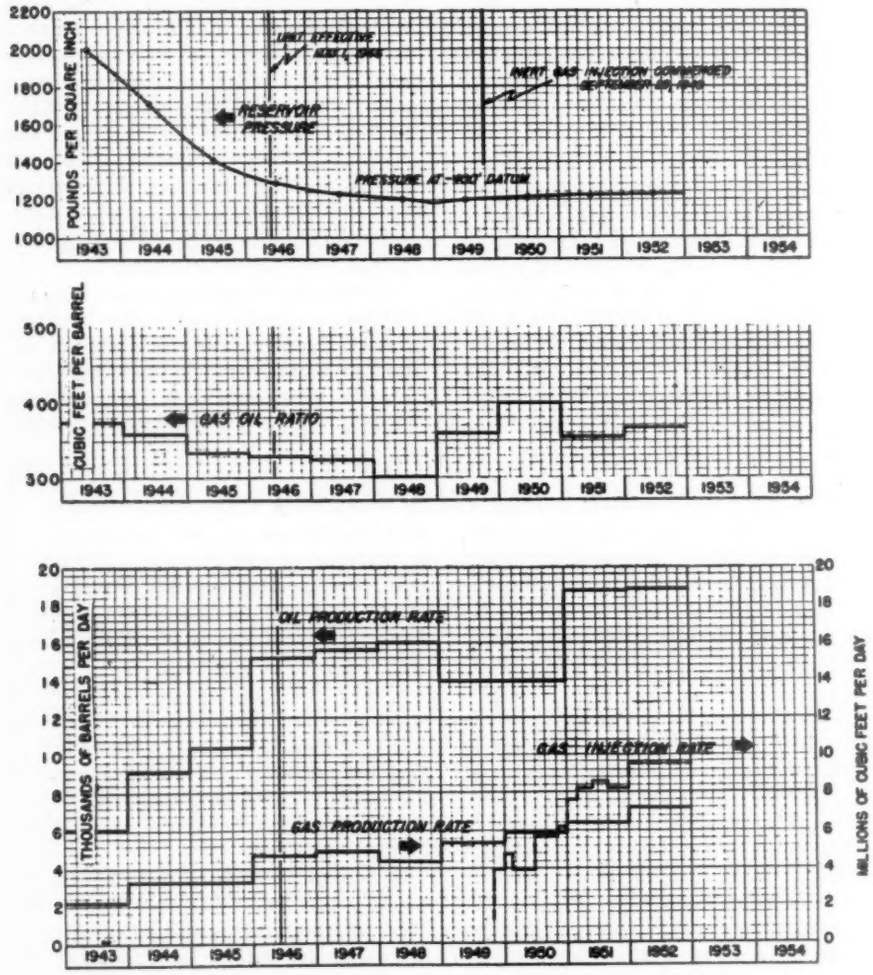
Schematic diagram sulfur recovery process at Elk Basin plant.

bbl per day. The increase in reservoir pressure has caused 16 wells to return to flowing after having been pumped prior to injection. Reducing the number of wells that have to be pumped has helped reduce operational costs.

Gas-oil ratios have remained near the solution gas-oil ratio except during periods of testing the high gas-oil ratio wells or during periods of low oil production when free gas must be produced to keep the gas plant in operation. The gas-cap has expanded uniformly down structure without channeling of injected gas.

The dominant producing mechanism in the reservoir at present is gravity drainage, sometimes referred to as gravity segregation. Results of all engineering studies to date indicate that this mechanism will result in a very high recovery efficiency. It is apparent that recoveries will be as good or perhaps better than recoveries normally expected with water drive. In any event the recoveries will be much greater than those which could have been expected under competitive operations without unitization. Fluid and reservoir characteristics are highly favorable to the gravity drainage mechanism. The injection program results in a high producing rate from the existing wells and allows the oil drained by gravity to be recovered with fewer producing installations.

The Embar-Tensleep operation lends itself to the application of much of the accepted reservoir engineering theory. This is possible because of the wealth of data collected throughout the life of the field. Reservoir data is still being meticulously recorded and some of it in new and ingenious ways. Bottom hole pressures on pumping wells are taken with a pressure bomb lowered between the tubing and casing thus saving the cost of pulling the rods and pump. Improved techniques and special equipment were developed at Elk Basin to facilitate the annulus method of bombing wells.* With annulus bombing, bottom hole pressures can be recorded cheaper and with less interruption of producing schedules.



Performance history of Elk Basin field, Embar-Tensleep reservoir.

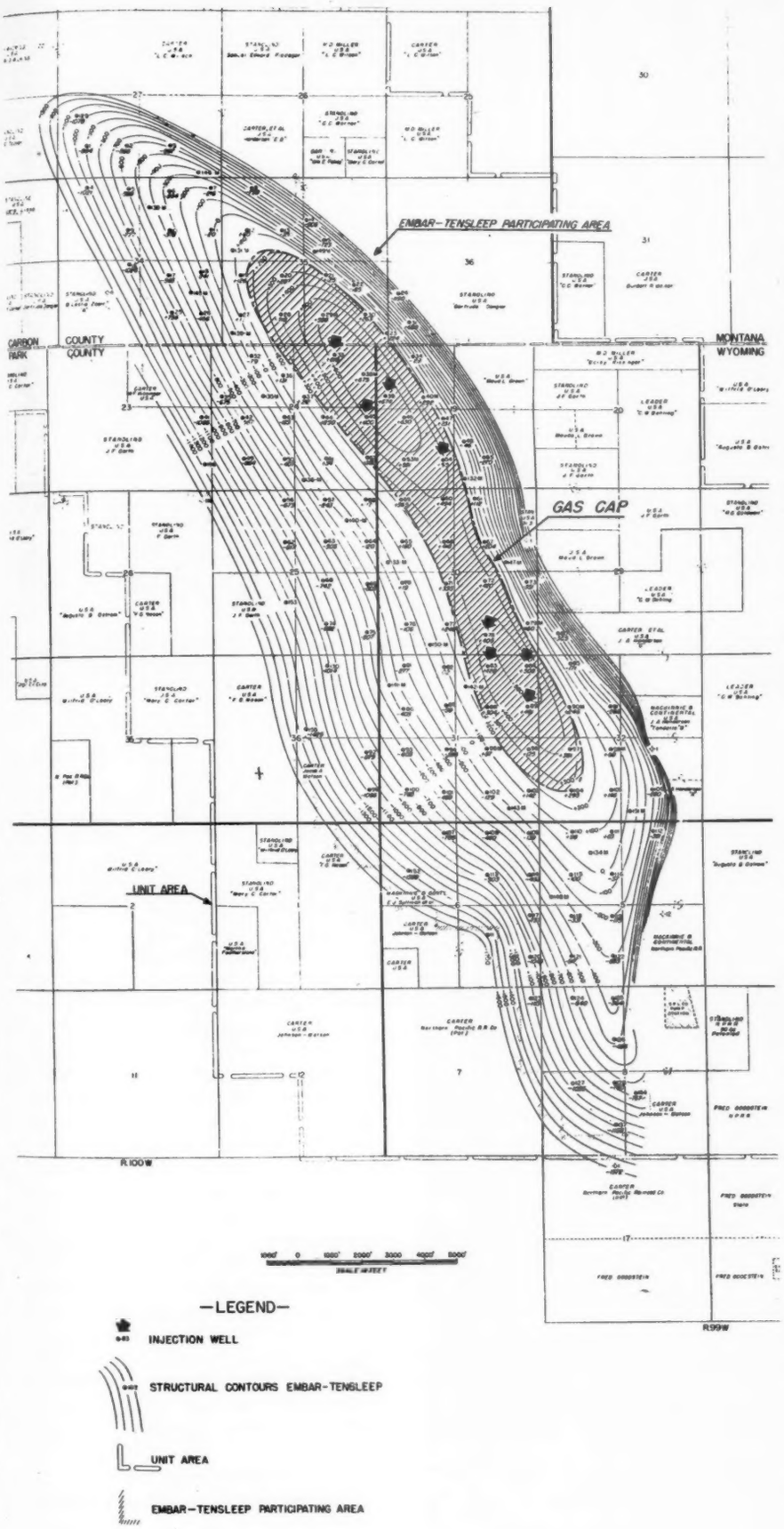
Operational Problems

One of the main operational problems at Elk Basin is the protection of personnel and equipment from the harmful effects of the sour hydrogen sulfide gas produced with the oil. The first step was to use galvanized stock tanks to store oil at the tank batteries. Early in the life of the field it was found that hydrogen sulfide combined with iron in the unprotected tanks and formed an explosive mixture of iron and sulfur. When the explosive combination was exposed to oxygen a tank fire sometimes resulted. Even if no fires resulted unprotected iron tanks were quickly corroded to uselessness.

Casing corrosion from the sour gas is combatted by lubricating inhibitors into the annular space. Flow lines and treaters are protected from electrolytic corrosion by using sacrificial anodes. Pipe lines are continually checked for "hot spots," then anodes are installed to inhibit the deterioration of the pipe. The casing and other well piping are protected from stray ground currents by using insulating nipples and flanges.

Sour gas presents a very serious operational hazard. Hydrogen sulfide paralyzes the olfactory nerve so that workmen have no way of naturally determining when a dangerous amount of sour gas has been inhaled. Therefore, many steps have been taken to

*API paper entitled "Design and Development of Improved Annular Survey Equipment and Techniques" by G. H. Reneau presented before the Rocky Mountain District of the API at its spring meeting held in Casper, Wyoming during April, 1952.



STRUCTURAL FEATURES OF ELK BASIN EMBAR-TENSLEEP RESERVOIR.

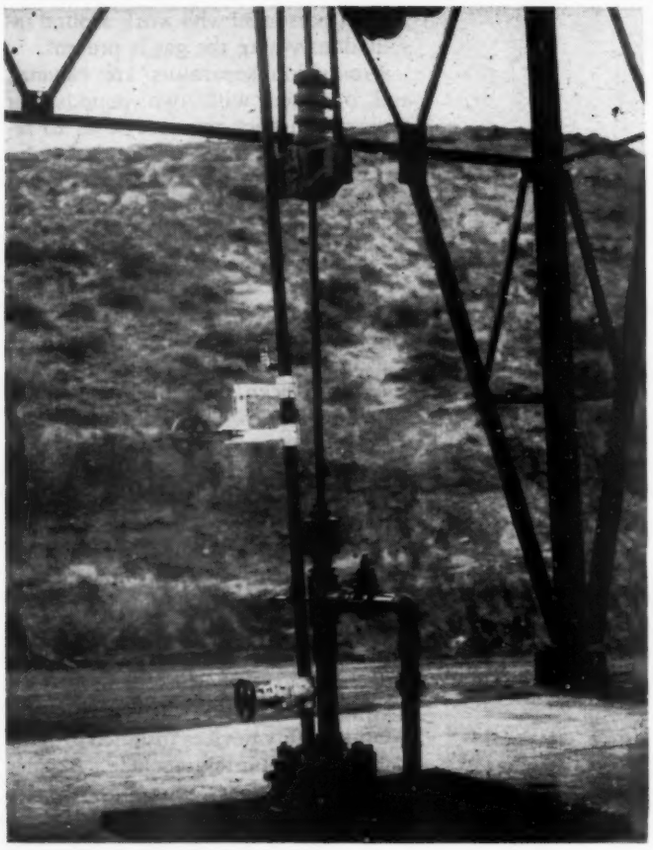
protect personnel who work around installations where the gas is present.

Production separators are elevated and operated with two pounds per square inch back-pressure so as to remove the maximum amount of solution gas from the oil. Thus, there is less gas effervescing from oil in storage and polluting the atmosphere around the tank batteries. Another advantage of elevated separators is that more complete separation results in a larger supply of raw gas for the gas plant.

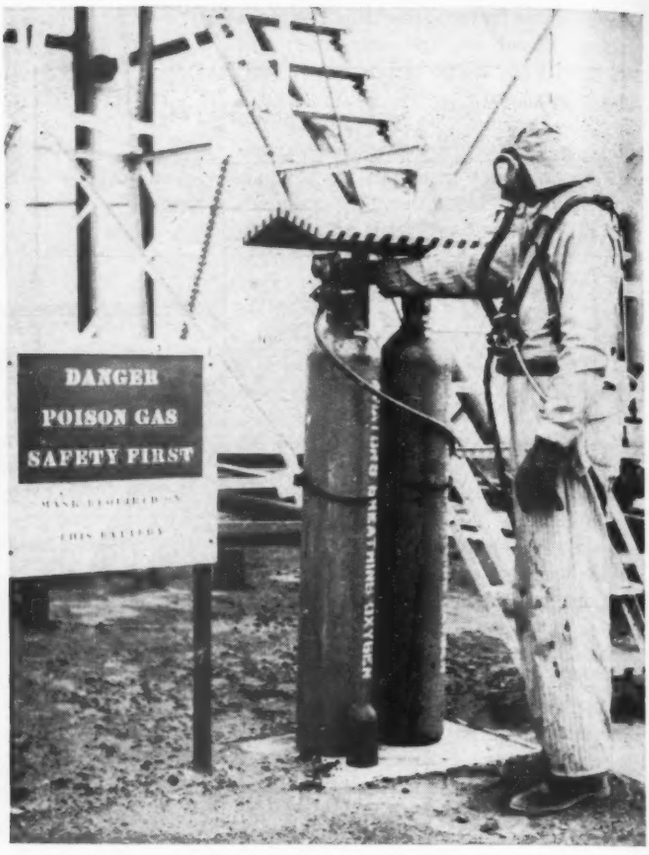
Manual cleaning of dirty tank "bottoms" has been nearly eliminated by installing hot rolling lines. All tank batteries have treater installations and when "bottoms" of a tank become too high for pipe line specifications the "bottoms" are circulated through the treater. Hot oil from the treater is routed back to the tank through a special piping system designed to scrub a major portion of the sludge and sediment from the bottom of the tank. Thus, the performance of a hazardous operation has been greatly curtailed.

Other safety devices installed around the tank batteries include oxygen breathing systems, sampling boxes, liquid level gages, and nitrogen blankets in the void space of the tanks. The sampling boxes afford pumpers and gagers the opportunity of sampling a tank at the customary three levels without using the cat walk and thief hatches. Liquid level gages allow pumpers to determine when to "switch" tanks without gaging from the thief hatch. Therefore, the risk of being exposed to sour gas while gaging or sampling tanks through an open thief hatch has been eliminated. Nitrogen is piped from the gas plant to all tank batteries and a blanket of nitrogen is maintained in the void space of the tanks at all times. This reduces the exposure of tank parts to sour gas and reduces the amount of hydrogen sulfide gas that escapes from the tank whenever the thief hatches are opened. All batteries have an oxygen breathing system installed. This is for use by personnel who must be exposed to sour gas while working around tank batteries. The oxygen mask is doned in a safe area and the user is constantly supplied with oxygen by means of a flexible hose connected to a high pressure oxygen source while working in the danger area.

Additional operational problems are created by the rugged terrain of the field and the severe weather that is experienced during the winter. Rough eroded outcrops in the field cause the preparation of well sites and access roads to be quite expensive in some cases. Winter temperatures may fall as low as —40 F, which causes drilling and production operations to be im-



Well head installation for annulus bombing.



Safety practices include using an oxygen mask while working in contaminated areas around tank batteries.

Rough terrain amplifies pipe lining problem.

peded with "freeze-ups" and other cold weather problems. In addition to cold weather, blizzard conditions may prevail which add further to winter operational difficulties.

Summary

Producing operations in the Elk Basin field are highly interesting, especially those pertaining to the Embar-Tensleep reservoir. This operation offers a good example of the benefits of unitization and pressure maintenance and is a tribute to the foresight of the operators in the field. The project not only assures the maximum recovery of oil from the reservoir, but also provides for full utilization of gas—a natural resource that was previously wasted by flaring. The sour gas which was only a nuisance prior to erecting the gas plant is now processed for its salable hydrocarbons and sulfur. In light of these features, the Embar-Tensleep operation can be considered an outstanding example of modern oilfield conservation practice.

Acknowledgement

The authors thank the management of Stanolind Oil and Gas Company for permission to publish this article. Deep appreciation is extended to all individuals who contributed many helpful criticisms and suggestions. * * *

Oil helps him serve your table . . .

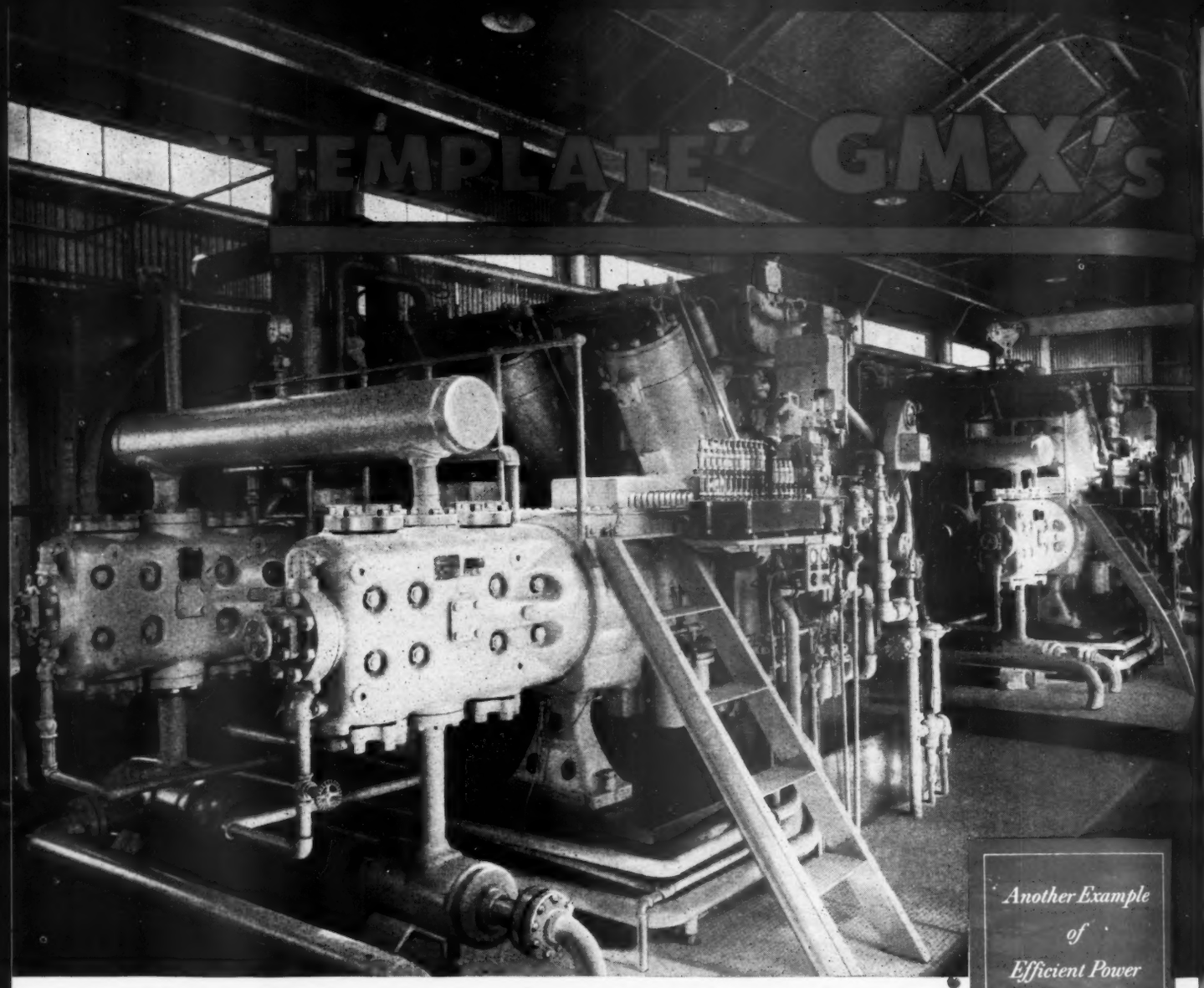
The food in the sea is worth millions and it's there for the taking. But to take it you have to be tough, bold, skilled. You have to work with a slippery, fish-filled deck under you and a pitching sea under that. You have to know the way of the water and the way of your catch.

For centuries, the fisherman's power was in the wind. Today, it's in his mighty, oil-lubricated Diesel or gasoline engine. Result: his job is safer, his payload bigger. America's annual seafood haul now stands at well over four billion pounds. The Texas Company has long been an important contributor of petroleum products to America's fishing industry.

The Texas Company

TEXACO

REG. T.M.



Another Example of Efficient Power at Lower Cost

ANGLE

Compressors

New York Washington, D. C. Bradford, Pa.

San Francisco, Cal. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash

XUM

PAY OFF 5 WAYS

in Shell's TXL gas lift system

THE compressors shown here are Cooper-Bessemer 330 hp GMX's in the Shell Oil Company operated TXL plant at Notrees, Texas. These units, with a capacity of about 7500 M.c.f. per day, supply the high pressure gas to 15 of the 23 wells being produced by gas lift. Here, residue gas from the nearby TXL gasoline plant is compressed from about 180 psi to 1100 psi. To maintain constant pressure with minimum manual control, the GMX's are equipped for automatic speed regulation and progressive automatic shutdown.

"Template" predesign is an important feature of these modern GMX's. Here are 5 ways it pays off:

1. Pre-engineering and pre-fabrication of all water, lube, fuel and compressor piping.
2. Greatly reduced installation time. (Can be compared to a skidded unit on permanent foundation.)
3. Elimination of costly steel skids.
4. No need to specify, order and expedite auxiliary equipment.
5. The V-angle GMX, simple and extremely compact, is ideally suited to template predesign and installation.

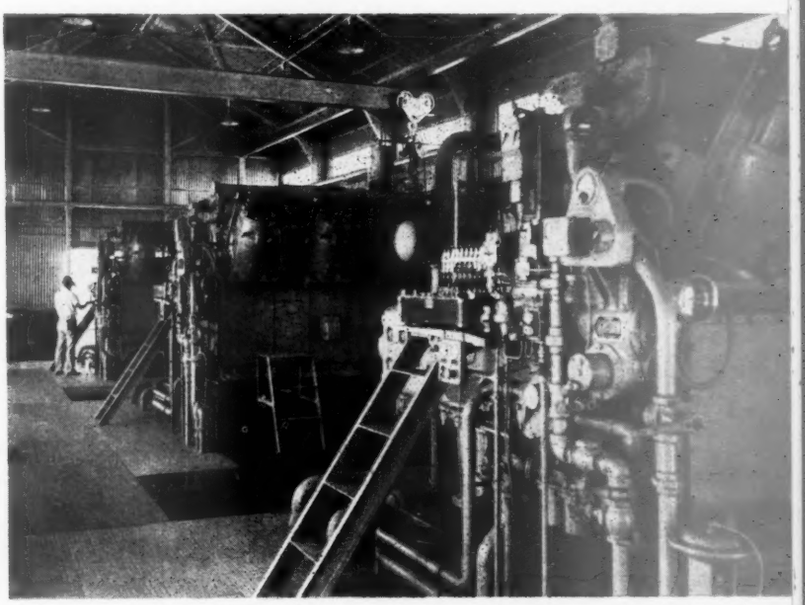
GMX compressors are built in sizes from 220 to 500 bhp.

Other Cooper-Bessemer V-angles, GMV's and GMW's, range up to 2500 bhp. Let the nearest Cooper-Bessemer office give you proof that these modern V-angles are easily your best bet.

TOP — This photo, from the compressor cylinder side, shows the 3 Cooper-Bessemer V-angles pre-engineered and fully equipped for complete "template" installation for gas lift service in the Shell Oil Company operated TXL plant, near Notrees, Texas.

LEFT — Gas lift compressor building housing the 3 "Template" GMX's. Capacity now totals about 7500 M.c.f. per day, with provision for expansion to 10,000 M.c.f.

RIGHT — The GMX's, shown here from the crank-door side, were furnished complete with all engine piping and auxiliary equipment, ready for fast, simple "template" installation on a concrete foundation.



's by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Tulsa Shreveport St. Louis Los Angeles Chicago

XUM

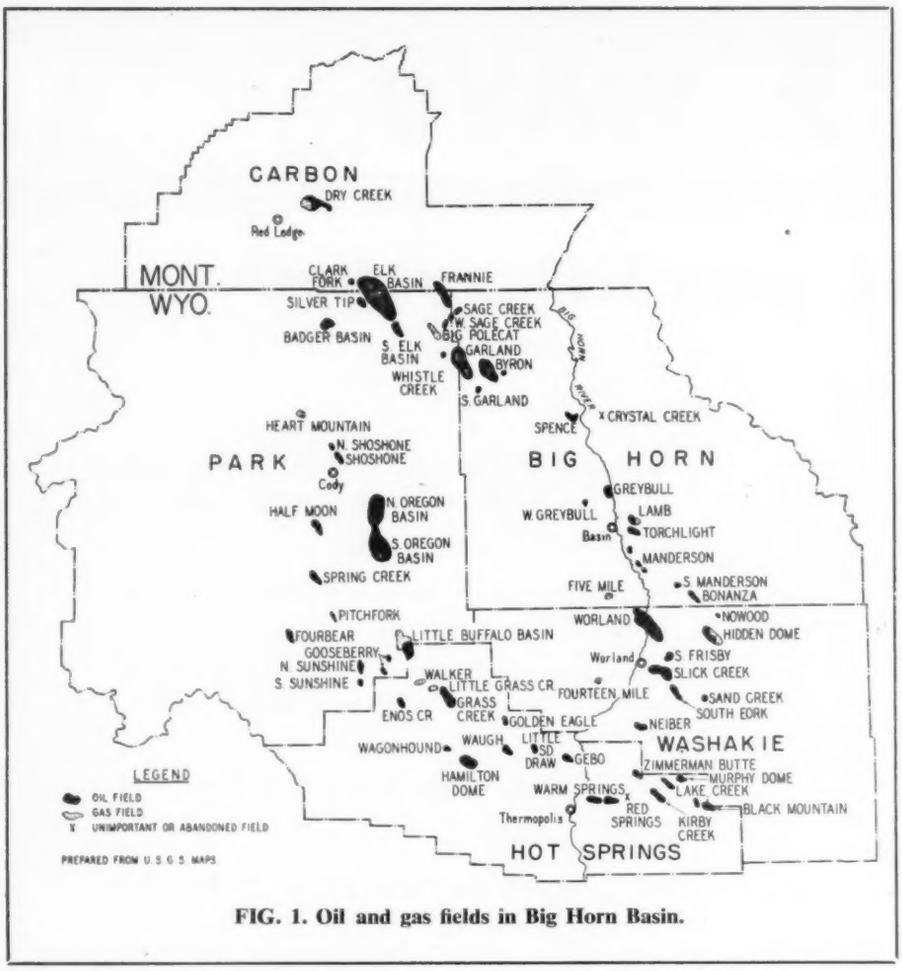


FIG. 1. Oil and gas fields in Big Horn Basin.

Wyoming and Montana

Characteristics of Crude Oils From Big Horn Basin Fields

W. J. WENGER* and W. J. LANUM*

Abstract

Analyses of 103 crude oils from Big Horn Basin fields have been compiled and tabulated in an abridged form according to the geological time periods of productive formations. The analyses, made by the Bureau of Mines routine method at the petroleum and oil-shale experiment station at Laramie, Wyoming, represent most of the fields and productive formations within the basin.

All low-sulfur oils were produced from Cretaceous formations while all oils with more than 0.5 per cent sulfur were produced from formations older than Cretaceous. Further correlations between types of oil and geological source are suggested. Similar correlations have been made in neighboring areas in the Rocky Mountains.

The information presented is useful from the standpoint of the geologist in predicting types of oils to be found and in correlating geological information, and from the standpoint of the production man and refinery man in judging value and utilization.

EXCLUSIVE

THE Big Horn Basin of Wyoming and Montana is one of the most important areas in the Rocky Mountain region, both from the standpoint of volume of oil being produced and from the rate at which new discoveries are being made. Consequently, characteristics of oils found in the various fields of the Basin are important to geologists, production men, and refiners. The analyses of 103 crude oils, as determined by the Bureau of Mines routine method, are compiled and discussed in this review.

Nine of the 20 largest producing fields in Wyoming in 1952 were in the Big Horn Basin; several are especially interesting. The Elk Basin field is the largest producer in the basin and is second only to the Rangely (Colorado) field in the Rocky Mountain region. It was discovered in 1915 but did not attain prominence until oil was discovered in the Tensleep sandstone in 1942. The first productive oil wells in the basin were drilled at the Garland and Greybull fields in 1906 and 1907. The Bonanza field is of interest because it is near the Bonanza oil spring, where the first indications of oil in the basin were found in 1884. The first producing wells, however, were not drilled until 1950 with discovery of oil in the Tensleep sandstone. Locations of many Big Horn Basin fields are shown in Fig. 1.

Analytical Method

This report is based upon data taken from crude-petroleum-analysis reports for oils analyzed at the U. S. Bureau of Mines petroleum and oil-shale experiment station, Laramie, Wyoming. Petroleums from Rocky Mountain fields, including Big Horn Basin oils, have been analyzed at this station since 1930.

Table 1 illustrates data obtained on oil from one of the new fields in the basin by the Bureau of Mines routine method of analysis.[1] Since 1950 Bonanza has become one of the 20 major producing fields in Wyoming and ranked as seventh largest producer in the basin by producing over 1,600,000 bbl of oil in 1952.

The Tensleep sandstone oil illustrated in Table 1 is very different from that issuing from the Bonanza oil spring. The former is a high-sulfur oil similar to other oils from the Tensleep formation in the basin. The oil from the spring is a low-sulfur green oil containing only 0.20 per cent sulfur. It contains only the higher-boiling gasoline components, the "light ends" apparently having been lost due to weathering. Low sulfur and other characteristics, however, indicate that its

*Chemist, Bureau of Mines, Laramie, Wyoming.

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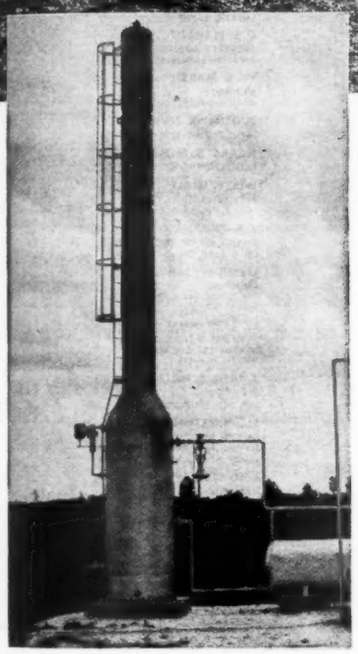

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At the Close of Business December 31, 1953

ASSETS

Cash on Hand and Due from Banks		$255,446,202.86
United States Government Obligations	$110,988,559.03	
Public Housing Authority Obligations (Fully Guaranteed)	12,975,830.31	
State, County and Municipal Bonds	13,373,910.48	137,338,299.82
Stock in Federal Reserve Bank		900,000.00
Other Bonds		219,098.00
Commodity Credit Corporation Certificates and Notes		22,287,142.32
Loans and Discounts		218,006,983.66
Income Accrued		1,483,209.60
Letters of Credit and Acceptances		3,130,333.37
Banking House and Equipment		7,257,013.95
Other Assets		93,864.31
		$646,162,147.92

LIABILITIES

Capital Stock	$15,000,000.00	
Surplus Fund	15,000,000.00	
Undivided Profits	4,897,107.54	$ 34,897,107.54
Reserve for Contingencies		2,802,369.60
Reserve for Taxes, Etc.		3,347,887.55
Deferred Income		470,898.91
Letters of Credit and Acceptances		3,130,333.37
DEPOSITS:		
Individual	$352,811,749.46	
Banks	234,509,119.03	
U. S. Government	14,192,682.46	601,513,550.95
		$646,162,147.92

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TABLE 1. ROUTINE ANALYSIS OF CRUDE OIL FROM TENSLEEP SANDSTONE, BONANZA FIELD, BIG HORN COUNTY, WYOMING.

Identification	General characteristics	
Sample PC-51-140	Specific gravity	0.846
Bonanza field	API gravity	35.8°
Tensleep sandstone, Pennsylvanian	Sulfur, per cent	1.87
2490-2528 ft	Pour point, deg F	below 5
Big Horn County, Wyoming	Color	brownish green
	Viscosity, S.U.S. at 100 F, sec.	37

Distillation, Bureau of Mines routine method

Stage 1—Distillation at standard pressure, 760 mm Hg absolute. First drop, 22 C (72 F)

Fraction number	Cut at Deg C	Cut at Deg F	Per cent	Sum per cent	Specific gravity 60/60 F	API gravity 60 F	C.I.	Aniline point, deg C	Viscosity 100 F S.U. secs.	Cloud test, deg F
1	50	122	2.3	2.3	0.634	91.7				
2	75	167	3.7	6.0	.661	82.6	3.2			
3	100	212	5.0	11.0	.698	71.2	11	61.9		
4	125	257	5.9	16.9	.726	63.4	15	59.0		
5	150	302	6.6	23.5	.754	56.2	21	55.0		
6	175	347	6.8	30.3	.781	49.7	27	50.2		
7	200	392	5.8	36.1	.801	45.2	30	49.8		
8	225	437	5.8	41.9	.818	41.5	33	53.9		
9	250	482	6.0	47.9	.835	38.0	35	57.7		
10	275	527	6.6	54.5	.853	34.4	39	59.6		
Stage 2—Distillation continued at 40 mm Hg absolute										
11	200	392	4.7	59.2	.879	29.5	47	61.2	41	below 5
12	225	437	5.6	64.8	.891	27.3	49	63.3	47	20
13	250	482	5.8	70.6	.909	24.2	55	64.2	60	40
14	275	527	5.2	75.8	.929	20.8	61	65.9	89	60
15	300	572	5.4	81.2	.939	19.2	63	70.2	175	80
Residuum			17.9	99.1	.995	10.7		too dark		

Carbon residue of residuum, 9.7% — Carbon residue of crude, 2.0%.

Approximate summary

	Per cent	Specific gravity	API gravity	Viscosity
Light gasoline	11.0	0.672	79.1	
Total gasoline and naphtha	36.1	.737	60.5	
Kerosine distillate	5.8	.818	41.5	
Gas oil	21.5	.861	32.8	
Nonviscous lubricating oil	10.5	.896–.930	26.4–20.7	50–100
Medium lubricating oil	6.1	.930–.942	20.7–18.7	100–200
Viscous lubricating oil	1.2	.942–.944	18.7–18.4	above 200
Residuum	17.9	.995	10.7	
Distillation loss	.9			

source is from among the Cretaceous formations.

Properties of Big Horn Basin Oils

Summaries of analytical data for 103 oils from the Big Horn Basin are shown in Tables 2-6. Oils discussed in this report were produced from formations in five geological time periods: Cretaceous, Triassic, Permian, Pennsylvanian, and Mississippian. Tables correspond to this arrangement.

The Big Horn Basin produces an appreciable percentage of low-gravity (API) black oils. Over half of the oils whose analyses are presented in this report are typical black oils (defined as containing 2 or more per cent sulfur, 5 or more per cent carbon residue, and with an API gravity of 26 deg or less). This does not represent the proportion of this type of oil produced, however.

Sulfur Content of Oils. When classified according to sulfur content, the oils fall into two very distinct classes—low-sulfur oil (0.50 and less per cent sulfur), and high-sulfur oil (over 0.50 per cent sulfur). With no exceptions, the Cretaceous oils fall in the first class, while oils from formations older than Cretaceous are in the second class. The highest sulfur content of 21 Cretaceous oils studied is 0.12 per cent. Sulfur contents of two Triassic oils are 2.59 and 3.07 per cent. Range of values for 33 oils from the Permian formations is 0.91 to 4.11 per cent sulfur. The range for 33 Pennsylvanian period oils is 0.85 to 3.96 and for 14 oils from the Madison limestone (Mississippian period), 1.41 to 4.24 per cent. This trend toward occurrence of low-sulfur oils in younger formations and high-sulfur oils in older formations has been noticed in other areas in the Rocky Mountain region,[2,3] but nowhere is it more distinct or clear cut than in the Big Horn Basin.

Pour Points. Cretaceous oils generally have low pour points, although 50 F was observed for an oil from Dry Creek, Montana; 45 F for Zimmerman Butte, Wyoming; and 45 F for an oil from Northwest Elk Basin, Montana. These high pour points are caused by the presence of paraffin wax, while the low pour points of 5 F and less that prevail among most of the oils indicate low wax concentrations. Pour points are also low among oils from Triassic, Permian, Pennsylvanian, and Mississippian formations. The occasional high value is due to the extreme viscosity of the oils rather than wax concentrations.

Gasoline Yields. As suggested by the gravities, straight-run gasoline yields are high for the Cretaceous oils. Oils in the other groups have rather low gasoline yields, except for the Golden

Summary of data showing sources and general characteristics of oils in the Big Horn Basin.

TABLE 2. FROM CRETACEOUS FORMATIONS.

Item	Field	State and County	Productive formation[1]	Approximate discovery date	Depth, feet	Gravity, deg API	Color[2]	Viscosity at 100 F S.U. secs.	Pour point, deg F	Carbon[3] residue, weight per cent	Nitrogen, weight per cent	Sulfur, weight per cent	Gasoline, volume per cent	Distillation residue, volume per cent
		Wyoming												
1	Badger Basin	Park	Frontier	1931	8,123– 8,476	46.0	green	32	<5	0.2	0.026	<.10	52.5	8.7
2	Bonanza Oil Spring	Big Horn	*	1884	surface	28.7	green	66	<5	.4	.045	.20	4.0	26.6
3	Byron, South	Big Horn	Frontier	1950	2,714– 2,757	53.5	NPA 3	<32	<5	.0	.002	<.10	68.9	2.4
4	Elk Basin	Park	Frontier	1915	1,540– 1,556	44.5	green	33	<5	.5	.030	<.10	47.2	12.5
5	Elk Basin, South	Park	Frontier	1950	4,950– 5,053	41.1	green	34	<5	.9	.030	<.10	40.5	13.5
6	Garland, South	Big Horn	Frontier	1950	3,225– 3,285	49.2	NPA 4½	<32	<5	.1	.005	<.10	64.7	4.4
7	Golden Eagle	Hot Spgs.	Muddy	1944	6,720– 6,776	62.6	NPA 1	<32	<5	—	—	<.10	86.3	3.0†
8	Golden Eagle	Hot Spgs.	Lakota	1945	7,379	51.8	NPA 1	<32	—	.1	—	<.10	54.3	5.6
9	Grass Creek	Hot Spgs.	Frontier	1914	1,047– 1,188	44.5	green	35	<5	.3	.032	<.10	45.8	13.2
10	Greybull	Big Horn	Greybull	1908	950– 965	49.9	NPA 7	34	20	.2	.005	<.10	43.9	11.5
11	Hidden Dome	Washakie	Frontier	1932	1,588– 1,612	43.0	NPA 2½	<32	<5	.0	.008	<.10	55.0	1.2†
12	Kirby Creek	Hot Spgs.	Frontier	1918	400–410	38.0	green	40	<5	.7	.051	<.10	32.8	21.2
13	Sand Creek	Washakie	Frontier	1947	6,710– 6,892	43.4	NPA 5	35	20	.2	.022	<.10	40.9	13.7
14	Shoshone	Park	Muddy	1926	1,083– 1,098	41.9	green	36	10	.3	—	<.10	40.6	17.2
15	Silver Tip	Park	Frontier	1948	5,939– 6,006	46.3	NPA 7	33	20	.2	.020	<.10	47.0	10.6
16	Worland	Washakie	Frontier	1946	7,300	56.4	<NPA 1	<32	<5	.0	.003	<.10	81.9	.8†
17	Zimmerman Butte	Hot Spgs.	Frontier	1946	1,115– 1,123	33.8	gr. blk.	49	45	1.4	.070	.12	21.7	28.0
		Montana												
18	Clark Fork	Carbon	Dakota	1949	7,548– 7,560	65.3	NPA 2	<32	<5	.0	.001	<.10	78.2	3
19	Dry Creek	Carbon	Pryor	1931	5,745– 5,803	47.6	green	34	50	.3	.008	<.10	39.3	8.6
20	Dry Creek	Carbon	Greybull	1930	6,033– 6,047	52.5	NPA 4½	<32	15	.1	.000	<.10	54.4	5.1
21	Elk Basin, Northwest	Carbon	Frontier	1947	3,376– 3,437	44.5	green	33	25	.2	.024	<.10	46.6	9.7
22	Elk Basin, Northwest	Carbon	Lakota	1948	4,400– 4,410	50.4	green	33	45	.3	.002	<.10	43.0	10.0

* Source rock of this oil is unknown; however, its characteristics indicate that it originated from a Cretaceous formation. Data on this oil were not used for making geological correlations.
† This value is not comparable because of final distillation temperature.

XUM

Summary of data showing sources and general characteristics of oils in the big Horn Basin.—(Continued)

TABLE 3. FROM TRIASSIC FORMATIONS.

Item	Field	State and County	Productive formation[1]	Approximate discovery date	Depth, feet	Gravity, deg API	Color[2]	Viscosity at 100 F, S.U. secs.	Pour point, deg F	Carbon[3] residue, weight per cent	Nitrogen, weight per cent	Sulfur, weight per cent	Gasoline, volume per cent	Distillation residue, volume per cent
		Wyoming												
23	Grass Creek	Hot Spgs.	Curtiss	1926	3,105– 3,115	24.3	br. blk.	135	<5	8.2	0.30	2.59	16.0	42.3
24	Hamilton Dome	Hot Spgs.	Curtiss	1918	2,520– 2,560	20.2	br. blk.	530	5	10.3	.33	3.07	9.5	49.3

TABLE 4. FROM PERMIAN FORMATIONS.

25	Black Mountain	Hot Spgs.	Embar	1926	2,956– 2,970	26.1	br. blk.	90	<5	6.3	0.27	3.02	18.8	38.4
26	Byron	Big Horn	Embar	1930	5,602– 5,700	18.2	br. blk.	1100	<5	12.2	.41	3.23	9.5	53.3
27	Enos Creek	Hot Spgs.	Phosphoria	1950	6,240– 6,300	27.1	br. blk.	115	<5	4.4	.18	1.01	8.4	40.0
28	Frannie	Park	Embar, Tensleep	1928	3,817– 3,830	24.3	br. blk.	110	<5	7.1	.22	2.78	16.3	40.7
29	Gebo	Hot Spgs.	Phosphoria	1943	4,558– 4,598	28.4	br. blk.	65	5	4.2	.20	1.83	15.9	34.6
30	Golden Eagle	Hot Spgs.	Phosphoria	1950	8,890– 8,930	48.7	NPA 6	<32	<5	.5	.002	.91	60.9	3.4
31	Gooseberry	Park	Embar	1937	5,880– 5,970	23.5	br. blk.	200	<5	9.9	.32	2.03	14.7	44.6
32	Grass Creek	Hot Spgs.	Embar	1922	3,838– 3,897	24.5	br. blk.	145	<5	7.4	.31	2.64	16.4	41.7
33	Halfmoon	Park	Embar	1944	3,426	14.1	br. blk.	>6000	15	10.9	.43	4.11	4.3	59.8
34	Hamilton Dome	Hot Spgs.	Embar	1919	2,325– 2,617	23.8	br. blk.	165	<5	7.8	.32	2.68	14.4	44.1
35	Kirby Creek	Hot Spgs.	Phosphoria	1944	3,492– 3,562	20.0	br. blk.	440	<5	7.9	.34	3.44	7.4	50.1
36	Lake Creek	Hot Spgs.	Embar	1925	3,690– 3,720	25.2	br blk.	97	<5	6.1	.25	2.87	18.4	38.3
37	Lake Creek, Northwest	Hot Spgs.	Phosphoria	1949	3,253– 3,367	32.6	br. blk.	44	<5	3.9	.16	2.27	31.9	25.3
38	Little Buffalo Basin	Hot Spgs.	Phosphoria	1944	4,404– 4,488	20.7	br. blk.	340	<5	8.2	.35	3.31	12.1	49.3
39	Little Sand Draw	Hot Spgs.	Phosphoria	1949	5,922– 5,962	36.1	gr. blk.	41	<5	2.5	.08	1.17	29.7	21.4
40	Neiber	Washakie	Embar	1947	10,025–11,000	40.6	NPA 6	<32	<5	.8	.010	1.88	54.6	6.8
41	Oregon Basin	Park	Embar	1927	3,444	23.3	br. blk.	160	<5	7.3	.31	3.03	16.2	43.7
42	Pitchfork	Park	Embar, Tensleep	1930	3,350– 3,822	15.7	br. blk.	2580	10	9.9	—	3.87	6.3	53.6
43	Shoshone	Park	Embar	1929	4,735– 4,809	19.7	br. blk.	410	<5	9.0	.34	3.43	13.5	49.4
44	Silver Tip	Park	Embar	1948	8,612– 8,656	43.2	NPA 4½	<32	<5	.3	.011	1.16	55.9	5.3
45	Slick Creek	Washakie	Phosphoria	1950	10,460–10,731	33.2	br. blk.	43	<5	3.4	.11	2.00	27.9	24.7
46	South Fork	Washakie	Phosphoria	1947	10,285–10,360	28.0	black	77	<5	6.5	.19	1.84	15.4	35.4
47	South Frisby	Washakie	Phosphoria	1949	10,580–10,665	32.1	br. blk.	46	<5	3.5	.14	1.82	27.2	26.5
48	Spring Creek	Park	Embar	1930	4,470– 4,525	15.0	black	3100	20	11.1	.44	3.93	5.5	58.9
49	Sunshine, South	Park	Embar	1926	2,480– 2,514	18.2	br. blk.	980	<5	10.0	.32	2.99	5.7	54.4
50	Wagonhound	Hot Spgs.	Embar	1944	4,278– 4,302	26.1	br. blk.	100	<5	5.8	.21	1.53	13.9	38.4
51	Warm Springs, East	Hot Spgs.	Embar	1916	900– 1,000	18.6	br. blk.	610	<5	8.5	.33	3.64	5.7	48.4
52	Warm Springs, West	Hot Spgs.	Embar	1916	1,000– 1,100	23.1	br. blk.	165	<5	6.9	.27	3.06	11.1	43.2
53	Waugh Dome	Hot Spgs.	Embar	1934	3,697– 3,730	26.8	br. blk.	86	<5	5.8	.21	1.74	15.9	35.2
54	Worland	Washakie	Phosphoria	1946	10,000	37.0	br. gr.	37	<5	1.2	.050	1.55	38.5	17.8
55	Zimmerman Butte	Hot Spgs.	Phosphoria	1945	4,240– 4,308	25.4	br. blk.	110	<5	5.9	.23	2.48	13.5	39.4
		Montana												
56	Elk Basin	Carbon	Embar	1949	5,978– 6,021	23.1	br. blk.	145	<5	10.1	.27	2.34	17.7	40.4
57	Frannie	Carbon	Phosphoria	1945	3,446– 3,479	26.8	br. blk.	72	<5	5.4	.19	2.60	18.4	36.7

TABLE 5. FROM PENNSYLVANIAN FORMATIONS.

		Wyoming												
58	Black Mountain	Hot Spgs.	Tensleep	1923	3,176– 3,245	23.3	br. blk.	180	<5	6.7	0.26	2.84	10.9	43.5
59	Bonanza	Big Horn	Tensleep	1950	2,490– 2,528	35.8	br. gr.	37	<5	2.0	.071	1.87	36.1	17.9
60	Byron	Big Horn	Tensleep	1930	5,163– 5,314	24.3	br. blk.	140	<5	6.1	.24	2.50	12.3	45.9
61	Crystal Creek	Big Horn	Tensleep	1919	964–997	18.6	br. blk.	540	<5	9.0	.36	3.95	8.9	50.3
62	Elk Basin	Park	Tensleep	1942	4,676– 4,856	30.8	gr. blk.	49	<5	3.9	.15	1.95	26.8	30.1
63	Elk Basin, South	Park	Tensleep	1945	6,898– 7,020	26.6	black	76	<5	5.0	.17	1.73	16.6	35.7
64	Enos Creek	Hot Spgs.	Tensleep	1948	6,417– 6,488	27.1	br. blk.	115	<5	4.3	.19	1.01	8.6	40.2
65	Fourbear	Park	Tensleep	1928	3,350	13.5	br. blk.	>6000	45	13.3	—	3.88	2.3	55.9
66	Frannie	Park	Tensleep	1928	2,734– 2,940	27.5	br. blk.	66	<5	4.6	.18	2.43	19.0	35.2
67	Garland	Park	Tensleep	1927–8	4,267– 4,389	23.0	br. blk.	140	<5	8.3	.22	2.77	13.4	40.3
68	Garland	Park	Amsden	1940	4,026– 4,060	22.0	br. blk.	180	<5	8.9	.27	2.88	13.3	42.8
69	Gebo	Hot Spgs.	Tensleep	1943	4,880– 5,103	23.5	br. blk.	160	—	8.6	—	2.71	13.0	39.7
70	Golden Eagle	Hot Spgs.	Tensleep	1949	9,350– 9,550	41.7	br. gr.	36	<5	.7	.028	.85	31.6	13.2
71	Gooseberry	Park	Tensleep	1937	5,881– 5,934	22.6	br. blk.	195	<5	8.5	.30	2.49	12.6	47.0
72	Grass Creek	Hot Spgs.	Tensleep	1922	4,236– 4,370	24.2	br. blk.	135	<5	7.8	.31	2.68	15.9	42.5
73	Halfmoon	Park	Tensleep	1945	3,590– 3,667	15.3	br. blk.	2940	10	10.7	.41	2.87	5.8	55.3
74	Hamilton Dome	Hot Spgs.	Tensleep	1929	2,602– 2,773	22.6	br. blk.	230	<5	7.5	.30	2.98	11.2	45.1
75	Hidden Dome	Washakie	Tensleep	1947	4,624– 4,757	19.7	br. blk.	460	<5	8.3	.33	3.45	9.0	49.6
76	Lake Creek, Northwest	Hot Spgs.	Tensleep	1949	3,587– 3,796	30.6	br. blk.	45	<5	4.1	.14	2.20	29.5	23.9
77	Lamb Anticline	Big Horn	Tensleep	1945	3,447– 3,470	25.0	br. blk.	97	<5	6.4	.20	2.77	16.8	35.1
78	Little Buffalo Basin	Hot Spgs.	Tensleep	1944	4,594– 4,853	20.7	br. blk.	320	<5	9.5	.38	3.14	12.8	49.2
79	Little Sand Draw	Hot Spgs.	Tensleep	1949	6,055– 6,119	35.0	gr. blk.	42	<5	2.5	.080	1.23	26.8	21.2
80	Manderson, South	Big Horn	Tensleep	1951	4,283– 4,318	36.4	br. gr.	38	<5	1.9	.071	1.68	34.5	18.4
81	Murphy Dome	Hot Spgs.	Tensleep	1949	4,390– 4,440	34.0	gr. blk.	43	<5	2.8	.11	1.70	29.3	22.6
82	Nowood	Big Horn	Tensleep	1950	1,611– 1,612	28.9	gr. blk.	48	<5	3.4	.11	2.45	26.4	26.0
83	Oregon Basin	Park	Tensleep	1927	3,380– 3,398	23.0	br. blk.	170	<5	7.2	.30	3.20	15.9	44.9
84	Pitchfork	Park	Tensleep	1930	3,463– 3,680	18.2	black	780	5	8.0	.35	3.49	7.8	54.0
85	Shoshone	Park	Embar, Tensleep	1929	4,390– 4,786	19.7	br. blk.	450	<5	9.1	.37	3.68	13.5	48.8
86	Silver Tip	Park	Embar, Tensleep	1948	8,737– 8,906	43.0	NPA 5	32	<5	.4	.009	1.13	55.9	5.5
87	Spring Creek	Park	Tensleep	1930	3,908– 4,000	15.3	black	2910	5	10.8	.42	3.96	6.2	58.1
88	Sunshine, North	Park	Tensleep	1928	3,780	14.7	br. blk.	4000	35	11.6	—	3.74	5.3	55.7
89	Torchlight	Big Horn	Tensleep	1947	3,176– 3,220	35.0	br. gr.	39	<5	1.6	.055	1.83	29.9	20.2
90	Whistle Creek	Park	Tensleep	1951	5,795– 5,825	27.9	br. blk.	63	<5	4.7	.11	1.84	19.5	35.0

TABLE 6. FROM MISSISSIPPIAN FORMATIONS.

		Wyoming												
91	Black Mountain	Hot Spgs.	Madison	1946	3,865– 3,874	20.3	br. blk.	380	<5	7.8	0.30	3.23	8.4	49.1
92	Elk Basin	Park	Madison	1946	5,156– 5,668	27.3	br. blk.	68	<5	6.4	.20	1.92	21.1	34.9
93	Frannie	Park	Madison	1929	2,925– 3,010	17.1	black	930	<5	9.2	.26	3.13	1.9	54.5
94	Garland	Big Horn	Madison	1930	4,025– 4,100	19.8	br. blk.	410	<5	9.6	.31	3.10	9.8	47.6
95	Hamilton Dome	Hot Spgs.	Madison	1948	3,308– 3,449	14.7	br. blk.	2900	5	11.4	.41	3.93	1.7	59.8
96	Lamb Anticline	Big Horn	Madison	1950	3,884– 3,990	18.2	br. blk.	810	<5	9.3	.25	3.08	6.7	48.1
97	Oregon Basin	Park	Madison	1943	3,930– 3,965	22.0	br. blk.	230	<5	9.0	.35	3.18	16.4	45.5
98	Red Springs	Hot Spgs.	Madison	1919	902– 1,082	10.7	br. blk.	>6000	45	13.0	—	4.08	.7	56.7
99	Sage Creek	Big Horn	Madison	1948	3,415– 3,450	19.7	br. blk.	450	<5	8.5	.25	2.95	4.4	49.9
100	Spence Dome	Big Horn	Madison	1944	434–470	18.5	br. blk.	580	<5	9.4	.30	3.13	6.9	48.9
101	Spring Creek	Park	Madison	1947	4,502– 4,579	12.6	br. blk.	>6000	30	11.6	.48	4.24	3.2	64.3
102	Torchlight	Big Horn	Madison	1948	3,550– 3,655	20.5	br. blk.	400	<5	9.5	.22	2.72	0.0	44.6
		Montana												
103	Elk Basin, Northwest	Carbon	Madison	1947	6,392– 6,860	32.5	br. blk.	45	<5	4.0	.104	1.41	26.2	25.4

[1] All productive formations listed are sandstones except the Embar, Phosphoria, and Madison, which are limestones.
[2] Colors of crude oils in these tables are designated as follows: Green; greenish black, gr. blk.; brownish green, br. gr.; brownish black, br. blk.; black; and NPA numbers.
[3] Carbon residue values were determined by the Conradson method, A.S.T.M. Designation D 189-46.

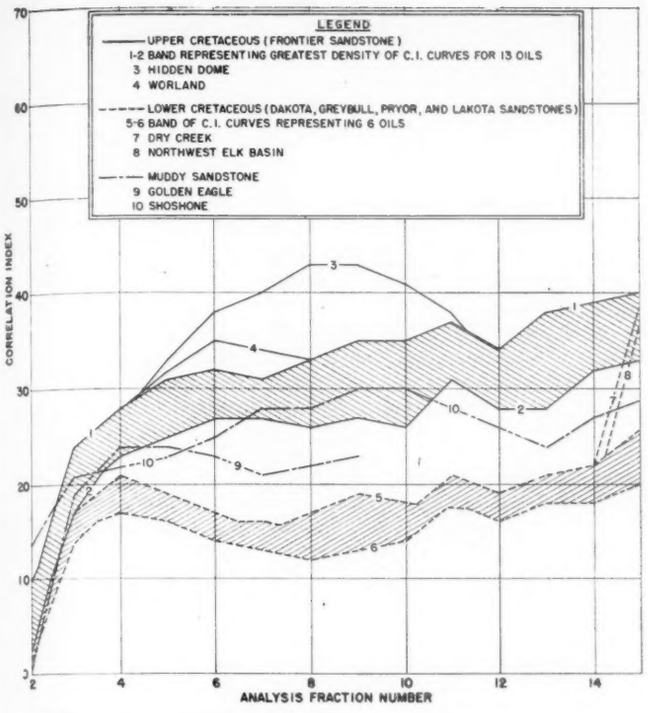
LEGEND
UPPER CRETACEOUS (FRONTIER SANDSTONE)
1-2 BAND REPRESENTING GREATEST DENSITY OF C.I. CURVES FOR 13 OILS
3 HIDDEN DOME
4 WORLAND
LOWER CRETACEOUS (DAKOTA, GREYBULL, PRYOR, AND LAKOTA SANDSTONES)
5-6 BAND OF C.I. CURVES REPRESENTING 6 OILS
7 DRY CREEK
8 NORTHWEST ELK BASIN
MUDDY SANDSTONE
9 GOLDEN EAGLE
10 SHOSHONE
CORRELATION INDEX
ANALYSIS FRACTION NUMBER

FIG. 2. Correlation index pattern representing oils from Cretaceous formations.

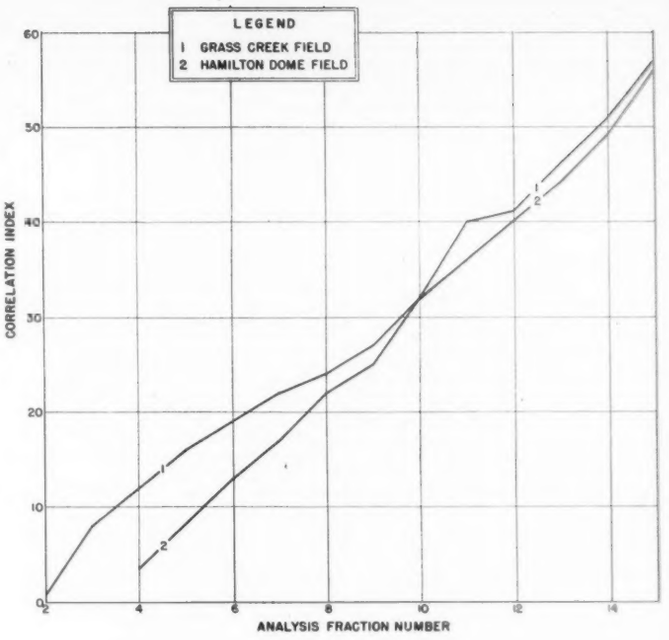

FIG. 3. Correlation index curves of two oils from a Triassic formation (Curtis sandstone).

Eagle, Silver Tip, Nieber, and Worland Permian oils and the Silver Tip Pennsylvanian oil. All these latter five oils are produced from deeper wells. It has been suggested that oils from the same formation in different fiields will have different characteristics, depending on the depth of the formation.[4]

Asphalt Contents. None of the Cretaceous oils are asphaltic, as indicated by the low carbon-residue values in Table 2. They range from 0.0 to 1.4 per cent. In contrast, the majority of Triassic, Permian, Pennsylvanian, and Mississippian period oils are very asphaltic. Carbon-residue values of the two Triassic oils are 8.2 and 10.3 per cent, Table 3. These values range from 0.3 to 12.2 per cent for Permian oils, Table 4; from 0.4 to 13.3 per cent for Pennsylvanian period oils, Table 5; and from 4.0 to 13.0 per cent for Mississippian oils, Table 6. The asphalt content of an oil is directly proportional to the per cent of carbon residue, and the yield of 100-penetration asphalt from an oil may be estimated by multiplying per cent carbon residue by the factor 4.9.[5]

Nitrogen Contents. Although determination of nitrogen content is not a regular part of the crude-oil-analysis method, nitrogen was determined for most of the oils listed in the tables. The importance of nitrogen content is recognized in the refining of petroleum because of adverse effects on cracking catalysts and stability of products. Nitrogen content can be useful, however, in identifying the source of certain oils. From the tables, it is apparent that Cretaceous oils have much lower nitrogen contents than those from older formations.

A previous paper[6] has indicated a correlation between carbon residue (a measure of asphalt content) and nitrogen content. Thus, as seen in the tables, high nitrogen content is usually associated with high carbon residue. A further correlation with geological origin was made in that the nitrogen:carbon residue ratio was found to be different for oils produced from different formations. Thus the ratio (per cent nitrogen/per cent carbon residue) was found to have the following values: Tertiary oils, 0.065; Cretaceous, 0.011; Jurassic, 0.012 Carboniferous, 0.030; Ordovician, 0.068; and Devonian, 0.019. These values were based on a study of oils from all over the United States.

The nitrogen/carbon residue ratios for the Cretaceous oils in Table 2 range from 0.007 to 0.130. If, however, a division is made into Upper and Lower Cretaceous, some order appears. The Frontier oils (Upper Cretaceous) have values from 0.033 to 0.130, with an average of 0.083 for 10 values. The Lower Cretaceous oils gave the three values 0.007, 0.027, and 0.025 averaging 0.019. The latter is much closer to the value suggested previously. The value found for the Upper Cretaceous oils is more similar to that given for Tertiary oils.

The Triassic oils give ratios of 0.037 to 0.032, but there are no comparative values.

For the Permian oils, 30 values range from 0.027 to 0.048 and average 0.038. This excludes the Golden Eagle and Nieber oils, which give low ratios (0.004 and 0.013). The Pennsylvanian oils show a range of 0.022 to 0.044, with an average of 0.036 for 30 oils. The Mississippian oils, for 12 values, average 0.032 over a range of 0.023 to 0.041. These average values compare with 0.030 as given for the Carboniferous period.

The ratio has various uses. Oil from the Bonanza oil spring is of unknown origin even though it was placed in Table 2. The nitrogen/carbon-residue ratio is 0.110. This suggests that its origin is either in the Tertiary or in the Upper Cretaceous formations. The nitrogen content for the Red Springs oil (item 98) was not determined. It may be estimated by multiplying the carbon residue (9.9) by 0.032, the value of the ratio for Mississippian oils. This gives a nitrogen content of 0.32 per cent.

Correlation Index

Correlation index, or C. I., values of analysis fractions of crude oils indicate types of hydrocarbons in the fractions.[7] They are functions of specific gravity and boiling range of the fractions. By

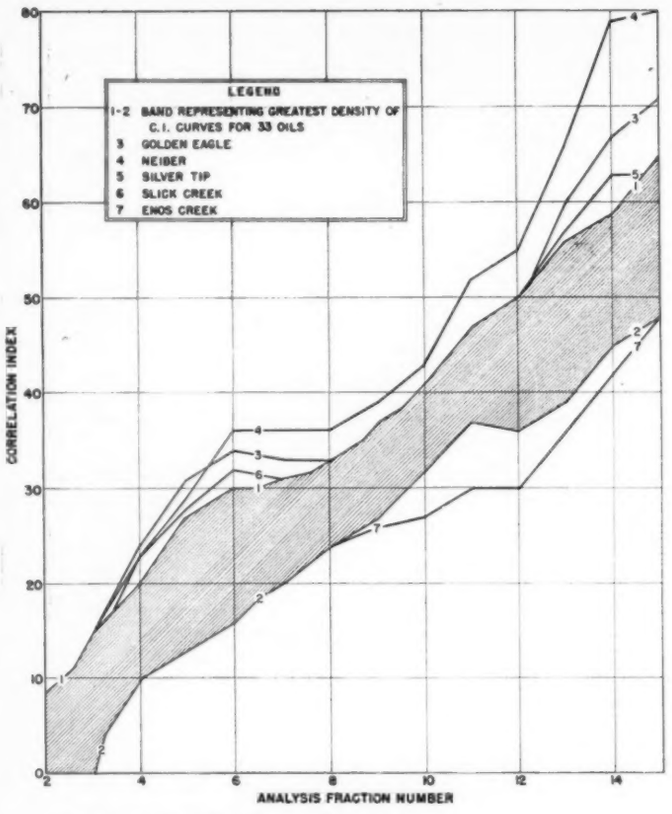

FIG. 4. Correlation index pattern of oils from Permian formations (Embar and Phosphoria).

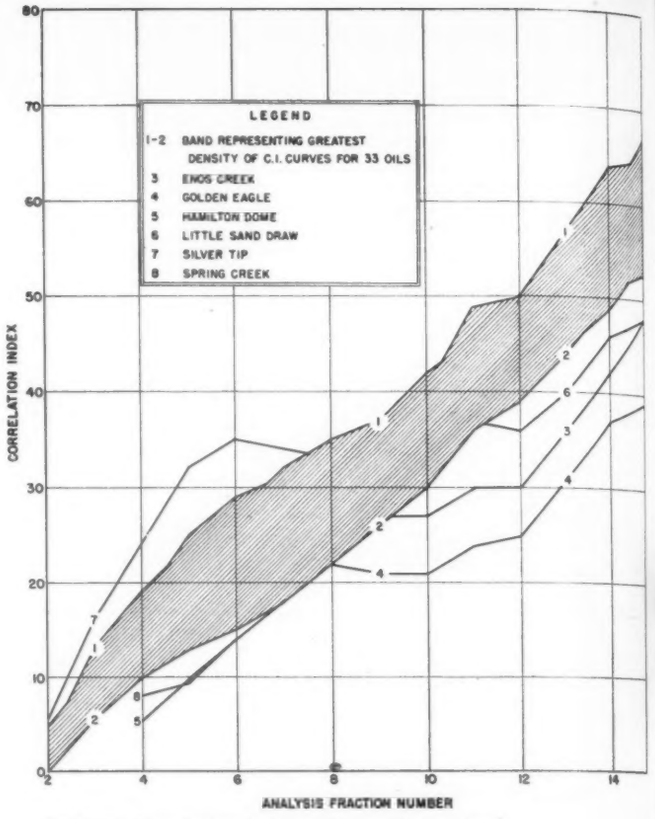

FIG. 5. Correlation index pattern of oils from Pennsylvanian formations (Tensleep and Amsden).

plotting the C. I. values against analysis fraction numbers, a C. I. curve is formed and is useful for comparing different crude oils or comparing one boiling range of a crude oil with other portions of the same oil. Although the values are not quantitative, concentrations of certain hydrocarbon types become obvious by comparing these curves.

Straight-chain paraffins have a C. I. value of 0, while benzene has a C. I. value of 100. Values for mixtures of paraffin, naphthene, and aromatic hydrocarbons will range from 0 to 100, depending on concentrations of the various components. An oil that is lower on the C. I. scale than others is interpreted as being more paraffinic and those that are higher on the scale are interpreted as being more naphthenic or aromatic. A curve that reaches a high point followed by a decline on the curve is interpreted as indicating a concentration of aromatic hydrocarbons in the boiling range included by the hump or peak.[5]

Comparison of C. I. curves for oils from a given productive formation usually indicates definite patterns that are characteristic of a geological time period in a given area. This was done in the case of the Big Horn Basin oils as illustrated in Figs. 2, 3, 4, 5, and 6.

Correlation-index curves for the Cretaceous oils are shown in Fig. 2 and are quite distinctive from those of the other time periods.[8] Fig. 2 also shows two types of curves indicating differences between oils from the Frontier sandstone in Upper Cretaceous and oils from formations in Lower Cretaceous. The latter are highly paraffinic, and their curves lie below those of the more naphthenic Frontier oils. Lines 1 and 2 enclose the band representing curves of the Frontier sandstone oils, and lines 5 and 6 enclose the band representing the other group. Lines 9 and 10 represent two oils from the Muddy sandstone which lies between the Frontier and the other group of formations stratigraphically. Line 3 represents oil from the Frontier sandstone at Hidden Dome field. This curve is of special interest because it indicates that this particular oil has an aromatic concentration in the gasoline and kerosine boiling ranges (analysis fractions 1-7 inclusive and 8-10 inclusive.) Another oil from Worland field, represented by curve 4, has a lesser aromatic concentration in the gasoline boiling range. All of the Cretaceous oils are more naphthenic or aromatic in the first part of the gasoline range than are most of the oils from older formations illustrated in Figs. 3, 4, 5, and 6. These Cretaceous C. I. patterns resemble very closely those of Cretaceous oils in several other structural basins in the Rocky Mountain region,[8] including the Julesburg Basin[2] and the Powder River Basin.[3] No distinction was apparent between Upper and Lower Cretaceous oils in these other areas.

Two Triassic oils from Grass Creek and Hamilton Dome are illustrated in Fig. 3. These were the only oils available from the Big Horn Basin to represent this particular time period and are not enough to establish a trend. The curves are similar to the majority of curves representing oils from the older formations and resemble some of the curves for oils from Jurassic and Triassic formations in other areas in the Rocky Mountain region.[3,8]

In Fig. 4, 33 oils were available to establish a definite trend for C. I. curves representing oils from formations of the Permian time period. Lines 1 and 2 enclose a band in which the density of curves is too great to distinguish individual curves. Several deviations from the general trend are indicated. Curve 4 illustrates oil from Neiber, which is more naphthenic than any of the others. Curve 7 represents Enos Creek oil for which the analysis fractions 8 to 15 are the most paraffinic of the group. Some of the oils in this group show aromatic concentrations in the gasoline boiling range as illustrated by curves 3 and 6 for oils from Golden Eagle and Slick Creek fields. The general trend for the Permian oils is to be very paraffinic in the first part of the

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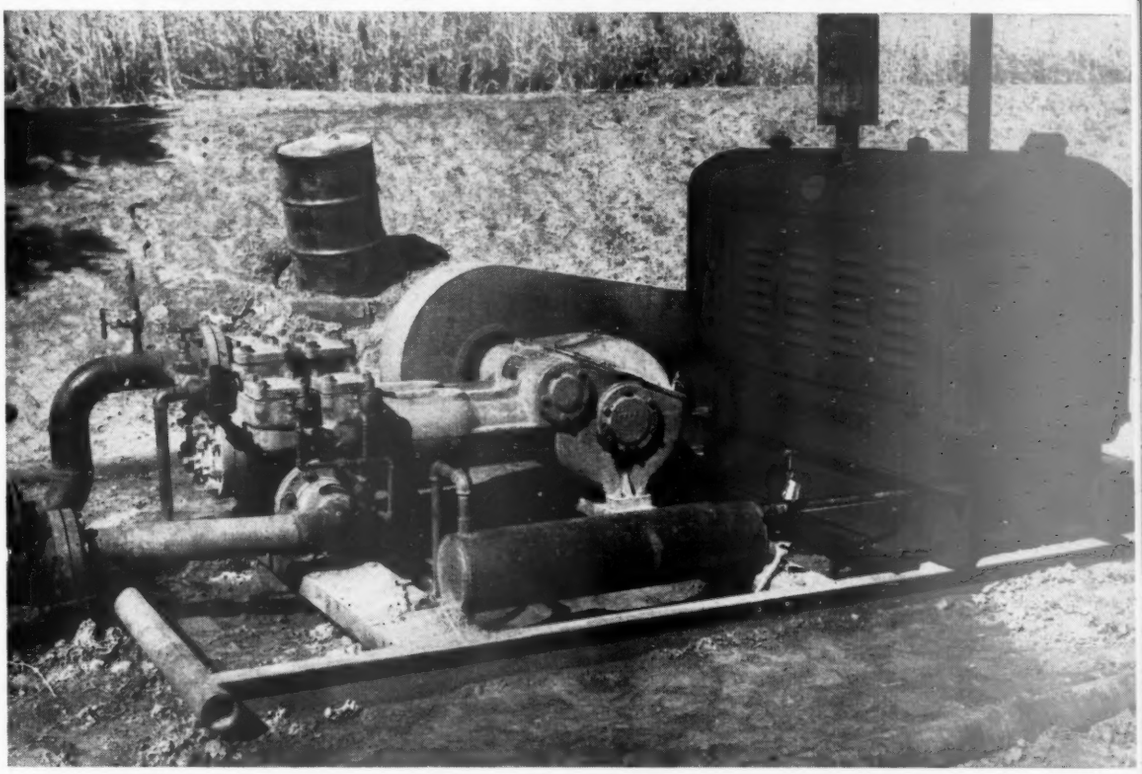

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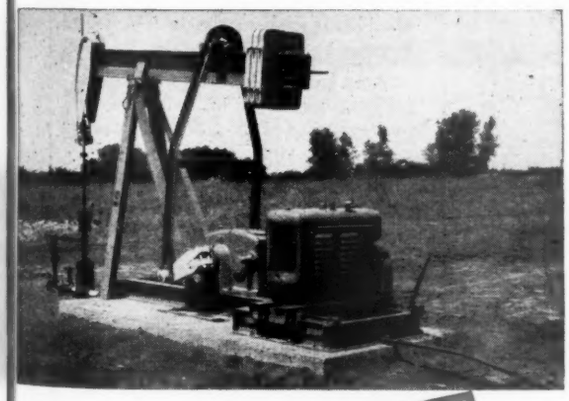

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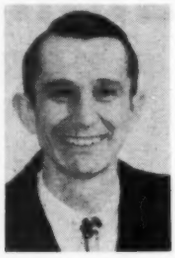

W. J. Wenger W. J. Lanum

W. J. Wenger is in direct charge of crude oil analysis work at the Laramie, Wyoming, station. He has been with the Bureau of Mines since 1942. He was born in Russell, Kansas in 1916, attended schools in Wyoming, and received a BS degree from the University of Wyoming in 1939. He was employed as a chemist by the Monolith Portland Midwest Company until the latter part of 1942.

W. J. Lanum has been a chemist with the Bureau of Mines since 1948. He lived most of his life in Denver, Colorado, where he attended Denver University. He was formerly employed as a development chemist at the Gates Rubber Company in Denver.

gasoline range and very naphthenic in the lubricating oil boiling range (analysis fractions 12 to 15, inclusive.)

Correlation-index curves for oils from the Tensleep and Amsden sandstones of the Pennsylvanian time period are illustrated in Fig. 5. Thirty-three oils are represented in this group. The general trend is illustrated by the band enclosed between lines 1 and 2. This band resembles that for Permian oils shown in Fig. 4. One difference is that fewer oils in this group show aromatic concentration in the gasoline range. Curve 7, representing oil from Silver Tip field, shows a considerable aromatic concentration. Curve 4 for oil from the Golden Eagle field is similar to those representing Cretaceous oils in Fig. 2.

Fig. 5 represents oils from the Madison limestone formation of the Mississippian time period. In this case the general trend is very similar to that in Figs. 4 and 5. No aromatic concentration, however, is indicated in any of the 13 oils represented. C. I. curves of the oils form a relatively narrow band between lines 1 and 2. Another characteristic reflected in this illustration is a deficiency in low-boiling material. Only two of the curves extend to analysis fraction 2.

Acknowledgments

This report represents the results of work done under a cooperative agreement between the Bureau of Mines, United States Department of the Interior, and the University of Wyoming. Acknowledgment is due to the various operators who provided oil samples for study and to Paul Biggs, petroleum engineer, U. S. Bureau of Mines, Laramie, Wyoming, and other Bureau of Mines engineers who collected geological and field data. The work was conducted under the general supervision of H. P. Rue, chief, Fuels Technology Division, Region IV, R. H. Espach, chief, Petroleum and Natural Gas Branch, Region IV, Bureau of Mines, and under the direct supervision of J. S. Ball, chemical engineer.

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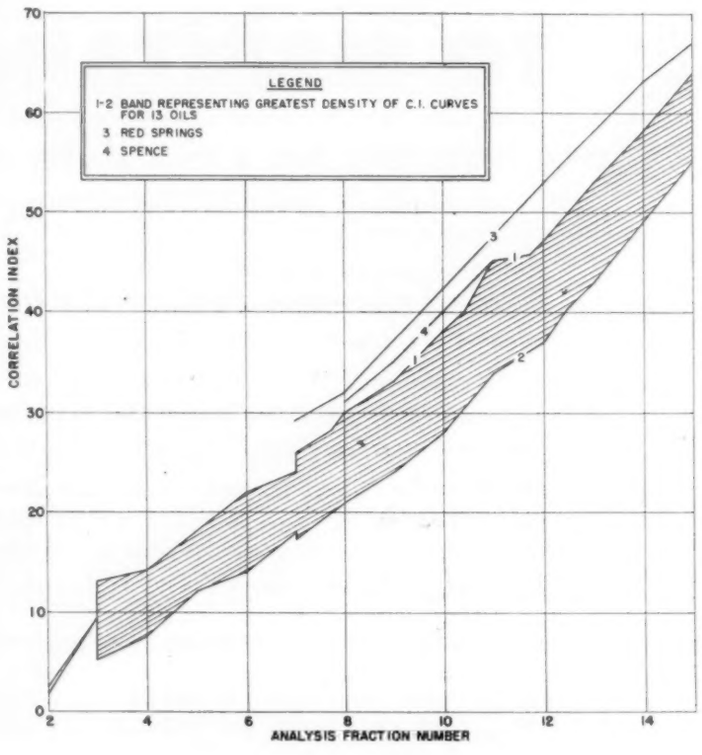

FIG. 6. Correlation index pattern for oils from a Mississippian period formation (Madison limestone).

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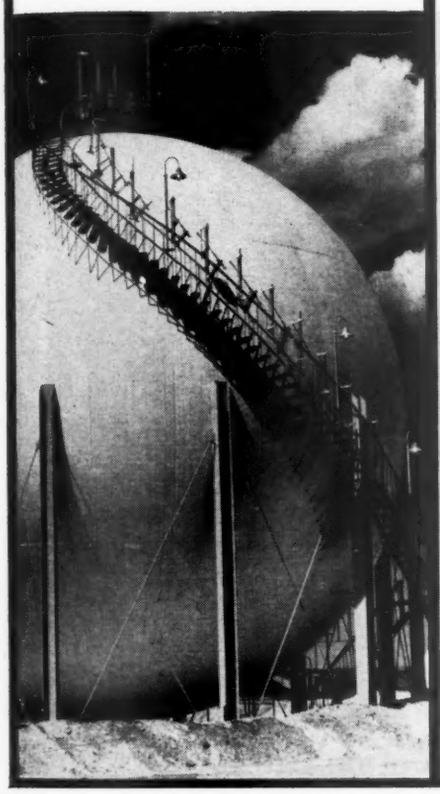

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Petroleum Profile

ONE of the most colorful figures in western oil is Alexander Hamilton Bell, president of the contract drilling firm of Bell and Burden, Inc., and a noted citizen of what Herb Caen calls "Baghdad by the Bay." Ham, as he is widely and popularly known, was born in Alameda, and he would like to make it clear that he is no relation whatever of Alexander Hamilton, the one time U. S. secretary of the treasury, although gossip has consistently made him a direct descendent of Aaron Burr's sparring partner. He is a tall, sparingly constructed sort of chap with an inexhaustible reservoir of physical and mental energy, and he has more friends up and down the California coast than a good humor man with free samples.

The story of Ham's entry into the oil business is an interesting bit of romance. His parents had prepared him for a career in art, and it would be difficult to imagine anyone more temperamentally fitted to spend a winter in a Montmarte garret with an easel, a jug of wine, and a loaf of bread, but it wasn't to be. Ham was attending Mark Hopkins Art Institute in San Francisco, and was showing real talent when the Bay City was shattered by the disastrous quake and fire of 1906.

It apparently shook Ham up, too, for a short time later, he abandoned his paints and palette, and assumed the significant post of office boy with Union Oil Company. That didn't hold him long, however, and he was soon back in the studios again, squinting with one eye at the models and wishing it was the ethical thing to do to open them both. But art as a profession was not for Ham. He had hardly settled down to serious work when World War I broke loose, and a projected trip to a Parisian art center had to be given up.

About 1915 he took another flyer in the oil business, this time with Associated Oil Company, on a refinery construction job from which later he was moved to Kern River oil field as production engineer. Thence he went to Bartlesville, Oklahoma, where for a number of years he divided his interest between refinery and field. For Cities Service Company he functioned variously as refinery engineer, assistant general superintendent of production, and chief production engineer. In 1922 he left Cities Service and attached himself to Pierce Oil Corporation as chief engineer in the refining department, but after a spell in Tampico, Mexico, he returned to his native California and there made the tie-in with Marland Oil Company that really shaped his entire future.

Continental Oil Company, Marland's successor, discovered the Seal Beach field while Ham was chief engineer. He later became general superintendent of the area, an experience that substantially amplified his knowledge of drilling and production technique. He was, in fact, sufficiently apprised on method and management by 1947 to form the contract drilling firm of Bell and Burden, Inc., with Dewey Burden, noted western industrialist as his partner, and together they took over Continental's drilling department with all its people and appurtenances, a venture that has proved highly successful.

Apart from business, Ham has been active in many industry organizations, particularly AAODC of which he is a national director. He is a past president of the California chapter, and he and his lovely lady, Dorothy, are frequent hosts at industry social affairs. He is a charter member of the Los Angeles Petroleum Club, is one of its most enthusiastic patrons, and has been a member of one or other of its committees almost since the Club's inception. He rides twice a year with that noted group of equestrians, the Rancheros Visitadores, and there are few people, indeed, who live their lives more fully or more enjoyably.

Ham still paints, and very well, too. One of his more recent efforts, indeed, a portrait entitled, "Incomplete Lady," hangs in a conspicuous corner of the Petroleum Club bearing mute testimony to the Bell artistry. On the other hand, a few hundred wells throughout the state bear articulate testimony to the Bell business acumen. So Ham probably made the right choice.

ALEXANDER HAMILTON BELL

President

Bell and Burden, Inc.

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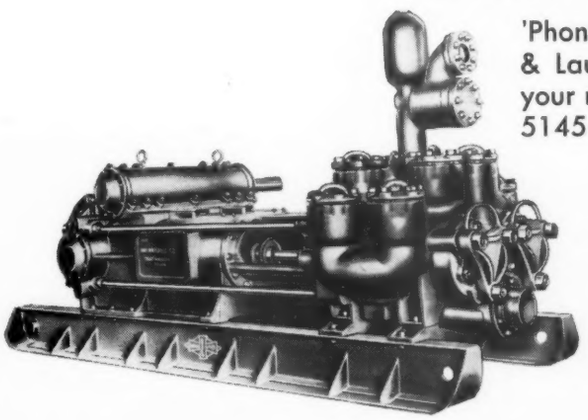

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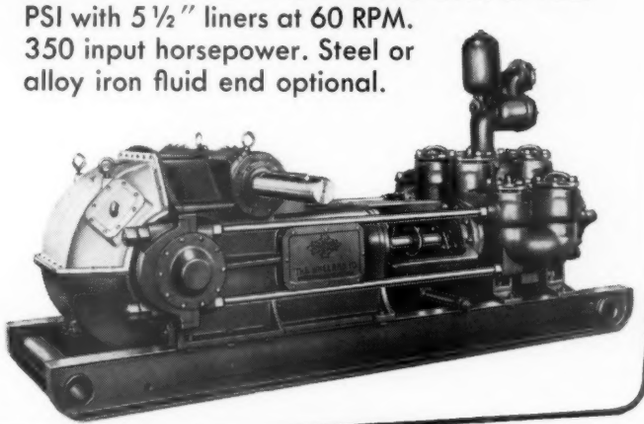

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Big Horn–Basin of Promise

TO the operator experienced in the sights and activities of the Gulf Coast, the aspect of the Big Horn Basin area of Northwestern Wyoming must present a forbidding sight. Ringed by towering mountains and with its geologically unexplored interior a rough, barren, and sparsely settled land, it seemingly could have but little to offer him. Yet if he will approach the inland basin with an alert and questioning mind, he will find here a truly great area of promise.

Twelve years before the turn of the century a well was drilled for oil near Bonanza but it was not until 1906 that production was first found in the Basin. Development following this discovery has been sporadic, hindered by the meager population, rugged terrain, weather, and lack of market. In spite of these developmental obstacles, however, more than seventy fields have been discovered, nearly 350 million barrels of oil have been produced, and today the known reserves approach 700 million barrels — twice as much oil to be produced as has been recovered to date.

That this has been accomplished in the face of the recognized difficulties is a tribute to both the operators and the area. The promise of the area becomes even more apparent with the consideration of the geological facets involved.

Early drilling was based primarily on surface geology, indeed almost three quarters of the producing fields have been discovered by this method. These fields generally are situated around the periphery of the basin and usually are characterized by local topographic depressions, structural indications in many being so obvious that their recognition was frequently credited to sheep herders.

The peripheral zone of the basin is even now not completely explored and still offers attractive structures for testing. In addition, the central portion of the 4200 square mile basin is covered by sediments of Tertiary age with other attractive structures undoubtedly hidden beneath the younger formation. Finally, less than 2 per cent of the known accumulations are attributed directly to stratigraphic traps, a major source of oil in other regions, and certainly a potential that cannot be ignored here.

In summary then, the Big Horn Basin must be commended as an area of tremendous potential and one where the surface has, both literally and figuratively, been but scratched.

Sim H. Crews

WITH A BAKER *Triplex* SHOE you secure

The difficult operation of cementing a string of casing at a predetermined point above the bottom of the hole, and at the same time protecting a permeable, low-pressure zone (or zones) below from cement contamination is being successfully performed with the Baker Triplex Cementing Shoe.

The features of design and construction which ensure success of the Baker Triplex Cementing Shoe are all "time proven" Baker principles. The Baker "Whirler" principle has proved to be far superior to undirected jetting action, which often fails to prevent cement channeling, and may wash out dangerous cavities with resultant contamination of the cement slurry.

STRONG SAFE CONSTRUCTION

The accompanying illustrations show how the full strength of the Triplex Cementing Shoe has been retained. There are no thin walls or elongated slots to weaken the shoe, and the operating mechanism is both sturdy and simple; see Fig. 1.

The Triplex Baffle Collar (Product No. 137 M&F, Fig. 2) stops the cementing plug a joint or two above the Triplex Shoe, thus retaining any cement tailings inside the casing and permitting only cement slurry of specified consistency to pass out the shoe.

The Triplex Float Collar, with spring-loaded flapper valve (Product No. 134 M&F, Fig. 3) likewise can be used as a stop for the cementing plug and provides an additional float valve in the casing.

POSITIVE BACK-PRESSURE VALVE

The spring-loaded flapper valve in Baker Triplex Cementing Shoes provides another important safety feature. While guiding and floating the casing, and when washing or conditioning the hole preparatory to cementing, the Baker Triplex Cementing Shoe operates as a conventional float shoe. The instant pump pressure is stopped, this flapper valve closes, and thereafter—even though leaks may develop in the casing or in the surface equipment—the *cement is held in place behind the casing until it sets.*

"CENTRALIZED" CASING ASSISTS OPERATION

By mounting Baker Casing Centralizers at suitable intervals above the Triplex Shoe throughout the zone to be cemented, the "centralized" casing presents a uniform annulus for placement of an effective sheath of cement. A Baker Casing Centralizer mounted immediately above the Triplex Shoe serves to center the Metal Petal Basket so that it expands uniformly against the wall of the hole, thus increasing its bridging effectiveness.

OPERATION OF METAL PETAL BASKET

The Baker Metal Petal Basket is attached to the Triplex Shoe in a manner that prevents it from being damaged during rotation or other movement of the casing. After the Basket has been released, the casing can be rotated without damaging the Basket. Figure 4 shows details of construction of the "Metal Petal" Basket which consists of a number of individual petals made of flexible sheet metal. These petals are mounted on reinforcing ribs, which in turn are mounted on a ring. The petals overlap each other (either in closed or expanded position) by sufficient margin to prevent cement slurry above the Basket from passing to the formation below.

After the hole has been washed and conditioned, the Baker Triplex Cementing Shoe is positioned at the desired cementing point and made operative as described on the opposite page.

The Baker Metal Petal Basket then expands to form a bridge even in large-diameter holes—readily conforming to hole irregularities over a wide range of diameters—and *retains the cement slurry above the Basket.* Lower, permeable, low-pressure zones are thus protected from contamination by the cement slurry.

GOOD "FIRST-TIME" CEMENT JOB

With the Basket expanded, forming a bridge at this point, cementing is commenced with the slurry being "whirled" upward around the "centralized " casing. Danger of channeling is practically eliminated, and by "whirling" (not jetting) the slurry, the possibility of washing out cavities is minimized.

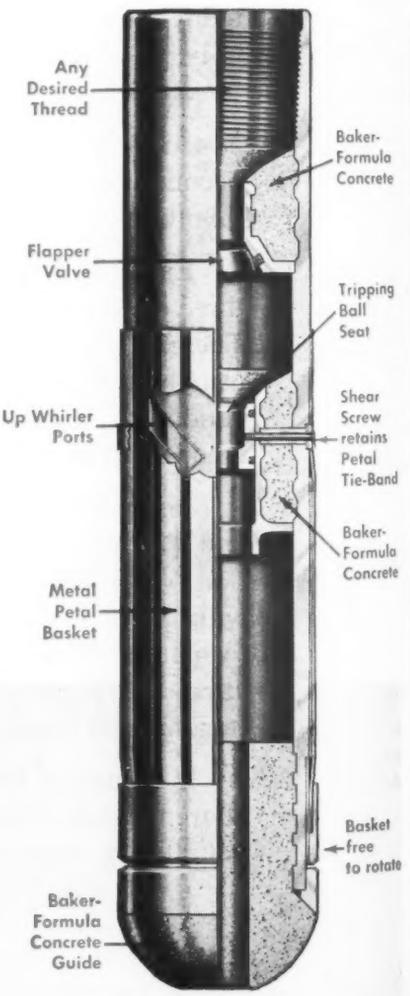


Fig. 1—Baker Triplex Cementing Shoe

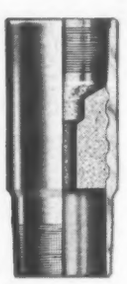


Fig. 2—Baker Male and Female Triplex Cement Baffle Collar

Fig. 3—Baker Male and Female Triplex Flapper Valve Float Collar

Fig. 4—Detail of Baker Metal Petal Basket

a good "FIRST TIME" CEMENT JOB

while protecting permeable, low-pressure zones below from cement contamination

HERE'S HOW THE TRIPLEX SHOE OPERATES

A A Baker M&F Cement Baffle Collar is installed a joint or two above the Triplex Shoe to stop the cementing plug so that cement tailings are retained *inside* the casing, or a Baker M&F Cement Flapper Valve Collar can be used where an additional float valve is desired.

B Baker Casing Centralizers are installed on, and above, the shoe joint to center the casing and provide a uniform annulus to receive the cement slurry.

C A Hold-Down Strap (secured by shear screws) retains the Baker Metal Petal Basket close against the Triplex Shoe while running-in the casing and conditioning the hole.

D Cementing Ports are covered by the Tripping Valve until cementing is commenced.

E A spring-loaded Flapper Valve permits passage of the cement slurry through the Triplex Shoe, but closes instantly to prevent any return flow of the slurry.

F After reaching the desired point in the hole, circulation is established through the ample central passageway. A Tripping Ball is now pumped (or allowed to gravitate) downhole to seat upon Tripping Valve and prevent circulation through the Shoe. Pressure of 400-500 psi is applied to the casing to shear the Tripping Valve Shear Screws and force the Tripping Valve downward to expose the cementing ports.

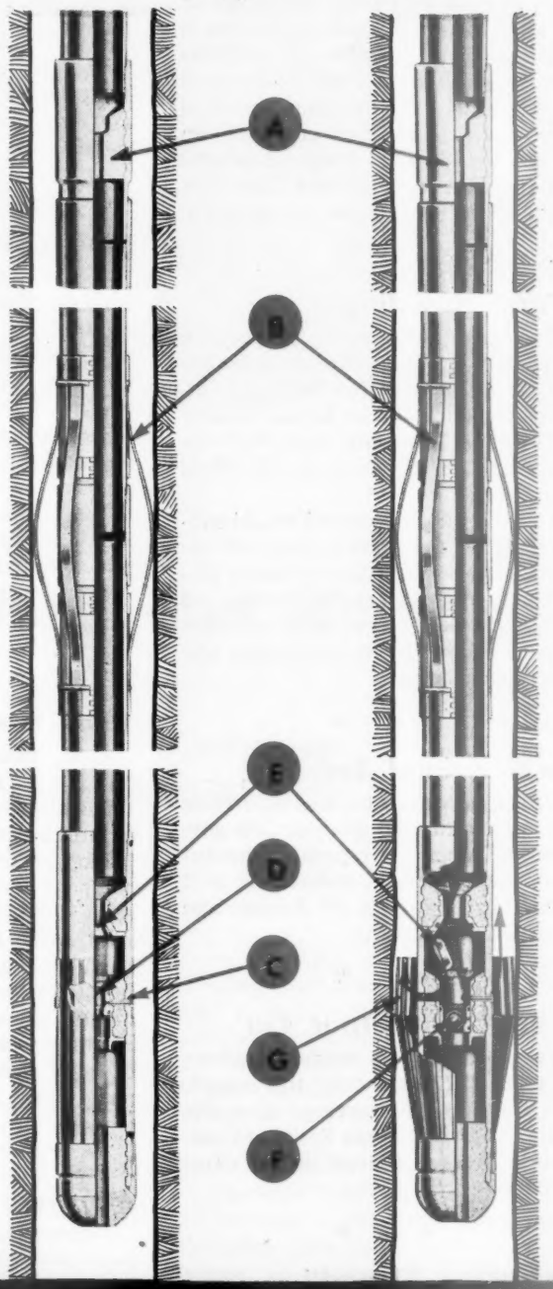
G Shearing these screws also releases the Basket Hold-Down Strap and allows the Metal Petal Basket to expand outwardly against the wall of the hole. The Basket has a wide range of expansion and forms a bridge in large-diameter or irregularly-shaped holes far beyond the range of a rubber packing element.

SUCCESSFUL CEMENTING FOLLOWS

The cementing operation is now carried out in the conventional manner with the cement slurry directed upward with the exclusive Baker "Whirling" action.

EASILY DRILLED OUT

Only readily drillable materials are used for all internal parts of the Baker Triplex Cementing Shoe; and two, one-half inch set screws hold the inner assembly stationary to facilitate drilling out.



CONTACT any Baker representative or office for complete details as well as specific recommendations for using Baker Triplex Cementing Shoes.

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BAKER *Triplex*
CEMENTING SHOE

Sacroc Unit Approved

Railroad Commission approval of the largest joint venture in the history of the oil business has been obtained with the consent for unitization of the 47,400 acre Sacroc unit covering the Kelly-Snyder and Diamond M reef fields of Scurry County. Magnitude of the effort required in this unitization is revealed by the number of operators and royalty owners, 1900, who agreed to the action. Commission approval was granted in the fact of opposition from a small group of operators who feel they are not receiving their just volume of oil under the present plan.

★ ★ ★

Water Flooding

The first large scale cooperative water flooding program ever to be operated in California has begun at Dominguez oil field in Los Angeles county by Union Oil Company, Shell Oil Company, and the Dominguez Oil Field Company.

The program is expected to add substantially to the known crude oil reserves of the field. Approximately $1,400,000 will be spent for drilling and well repair operations, plus an additional $350,000 for water treating and injection facilities.

★ ★ ★

Mexico Goal Set

Petroleos Mexicanos will be drilling 700 wells in Mexico this year, the government monoply reports. Current drilling pace, it was claimed, is at 2 wells daily in various oil districts and in exploratory drilling.

★ ★ ★

Texas Oil Output Cut

Texas has cut its crude oil allowables by 40,206 bbl daily this month. This makes a daily average allowable of 2,830,448 bbl. Texas Railroad Commission ordered the cut in an effort to reduce excess stocks.

★ ★ ★

Cambrian "Trend"

Operators have taken another look at the entire area between the White Flat multipay field of Nolan County and the Bronte field of Coke County realizing that the Cambrian, long discounted as a possible reservoir because of the supposed absence of potential source beds, now offers a prime drilling target. Further emphasis on the possibilities of the Hickory sand and Wilberns dolomite was added by Kilroy Oil Company's No. 1 Roberts in the Southeastern part of Nolan County. Completed in the Cambrian through perforations 6102-17, the well flowed 323 bbl of 52 deg oil in six hours with a gas-oil ratio of 138 cu ft per barrel. Lease play in the whole area has become active with bonuses ranging up to $1000 an acre and overrides being given.

★ ★ ★

Pipe Corrosion Causes

Addressing the Dallas Chemical Engineer's club at the January 1954 meeting, Dr. D. M. Updegraff, microbiologist for the Magnolia Petroleum Company, stated that sulfate reducing bacteria have been found responsible for corrosion of external surfaces of well casing at depths 5000 ft below the surface.

While this type of corrosion is recognized for surface conditions, new research discloses that soil bacteria are present in an active state at considerable depths.

★ ★ ★

Reef Well Fracture

Completed as a marginal producer, Sun No. 1 Damery in Macon County, Illinois produced only 510 bbl of oil in three months from its reef zone completion at 1948 ft. Late in December company fracture treated 12 ft interval, using 448 bbl of fluid and 10,000 lb of sand. After cleaning, the well was capable of producing more oil per day than it had recovered in the first three months it was pumped and at the end of three weeks it still had a flowing capacity of more than 300 bbl per day on a choke.

★ ★ ★

Marlowe Company

George O. Baird, Jr., Shreveport independent oil operator, and Mark V. Marlowe, Kentucky coal operator, have organized the Marlowe Petroleum Company, which will operate over the Mid-Continent area. Company will purchase leases, royalties, drilling blocks, and provide development capital in this area. Headquarters are in Giddens-Lane Building, Shreveport.

Oil Search in Israel

"Oil exploration in Israel is proceeding satisfactorily," reports Max W. Ball, oil and gas consultant of Washington, D. C., recently returned from two months in the Middle East.

"The first exploration licenses were granted last June, under the petroleum law of 1952 that opened the country to foreign oil companies. In the subsequent six months four groups, operating on behalf of seven companies or individuals holding interests in 32 licenses, have spent around $600,000, not counting investment in drilling equipment.

Exploratory activity extends from Haifa Bay and Mt. Carmel on the north, south through the coastal plain to beyond Gaza, thence across the northern Negev to the Wadi Araba, and north beside the Dead Sea to Ein Gedi at the Jordan border.

★ ★ ★

Oklahoma Proration

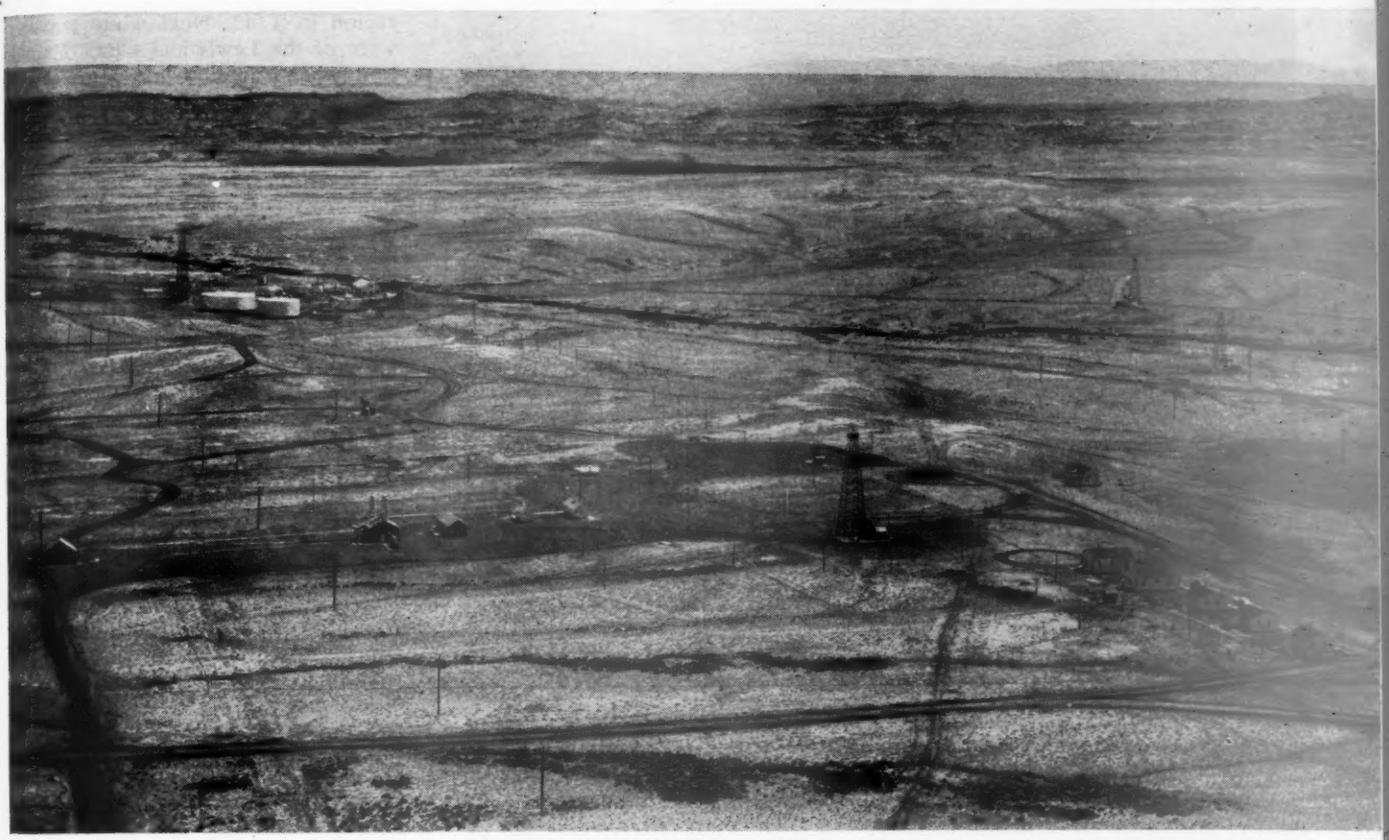
State oil men and officials of Oklahoma Corporation Commission have met to discuss measures to improve poor oil and gas proration system. Two important remedial actions have grown out of the meeting and immediate steps to implement them are being taken. First of these is to obtain for the Commission a complete list of the producing wells of the state with a proration schedule for each well. This may substantially be accomplished in February. The second recommendation is appointment of committees to completely overhaul present commission rules and regulations. This is obviously a long term objective, but should result in vastly improved operating conditions eventually.

★ ★ ★

Rocky Mountain Drilling

Operations in 1953 exceeded previous peaks by almost 50 per cent, it is reported. In the 11 mountain states, 3417 wells were drilled last year, exceeding the 1952 total by 1060, and again emphasizing the tremendous potential of the area.

The 1037 wildcats produced 144 discoveries for a success ratio of almost 14 per cent. Development wells attained a ratio of 83 per cent for 1977 successful wells out of 2380 attempts. Local operators foresee a continuation of the drilling rate with possibly more emphasis on development wells in 1954 as markets and outlets improve.



Air photos of Oregon Basin, showing producing wells, storage, treaters, roads, camp, etc. — *Jack Richards Photo.*

Big Horn Basin—Wyoming and Montana

Extensive review of the history, geology, and petroleum reserves of this Rocky Mountain sedimentary province

M. M. JOHNSON

THE Big Horn Basin is situated in Northwestern Wyoming and South Central Montana. The structural depression continues northwesterly into Montana, entitled the Crazy Mountain Syncline. Division between the Big Horn Basin and the Crazy Mountain Syncline is generally considered to occur at the Dry Creek oil field, Carbon County, Montana. (See map). In area the Big Horn Basin covers approximately 4200 square miles, not counting the mountain slopes. The Big Horn Mountains form the eastern rim; Bridger Mountains and Owl Creek Mountains form the southern rim, and the Absaroka Ranges from the western rim, with the Crazy Mountains of Montana completing the mountainous rim.

The Author

M. M. Johnson is a consultant in petroleum geology in Cody, Wyoming. He studied geology at the University of Idaho, and has done oil geology in all the oil - producing states and Canada. He was chief geologist for the Husky Oil Companies, in Cody, before setting up his own consulting office.

EXCLUSIVE

The Big Horn Basin is both a structural and a physiographic basin. Elevations within the basin are mostly on the order of 3800 to 5500 ft. Some mountains within the basin, however, rise considerably above 5500.

The Term "Basin"

The word "basin" as used in this part of the west is oftentimes confusing to outsiders. The term is used in two senses. In addition to the Big Horn Basin as defined above, we shall note such terms as "Elk Basin," "Oregon Basin," and others. These latter are small topographic depressions rimmed by an escarpment of hills formed by resistant rocks. These are usually anticlinal in structure and several of the

— *Jack Richards Photo.*

Husky Oil Company No. 1 Two Dot Ranch, wildcat with Absoroka Mountains in the background. Close up and air photo taken in early winter.

most important oil fields are situated within these small basins, all, in turn, within the Big Horn Basin.

Accessibility, Drainage

Despite the almost complete rim of mountains around it, the Big Horn Basin is easy of access. There are low divides, passes, and River Canyons through which traffic passes. Drainage of the region is all tributary to the Yellowstone River. The principal tributary of the Yellowstone is the Big Horn River, its principal tributaries are the Shoshone and Clark's Fork rivers. (See map). It is interesting to note that the Big Horn River and the Wind River of Wyoming are the same stream. Across the mountains to the south in the Wind River Basin this stream is called the Wind River; however, as the river emerges from the Wind River Canyon, it is then called the Big Horn as it flows northwardly. Both names are official.

The subject region is sparsely populated, having a population of about 25,000 persons. These people are chiefly occupied in livestock raising, agriculture, and oil production. It is with the production of petroleum that we are concerned.

Historical

So far as is known, the first white men to visit the region were the Verendryes, French Canadians searching for a water course to the Pacific. It is problematical whether they actually were in the Basin, but they were certainly in the region in 1742. Next white travelers were of the Lewis and Clark Expedition, when Captain Clark camped near the mouth of Pryor Creek in July 1806.

One of Clark's men, John Colter, was definitely in the Basin in 1807. In 1811 Wilson Price of the Astor Expedition crossed the Big Horn Range into the Nowood River area. In these times men were chiefly concerned with furs.

In about 1824 gold was discovered at South Pass in the Wind River Mountains to the south, and mining people moved into the area. Metal mining amounted to very little and soon men were in search of other treasure. It was not hard to find. The grass grew everywhere, the cattle men took over, and to this day it is an important cattle-grazing region.

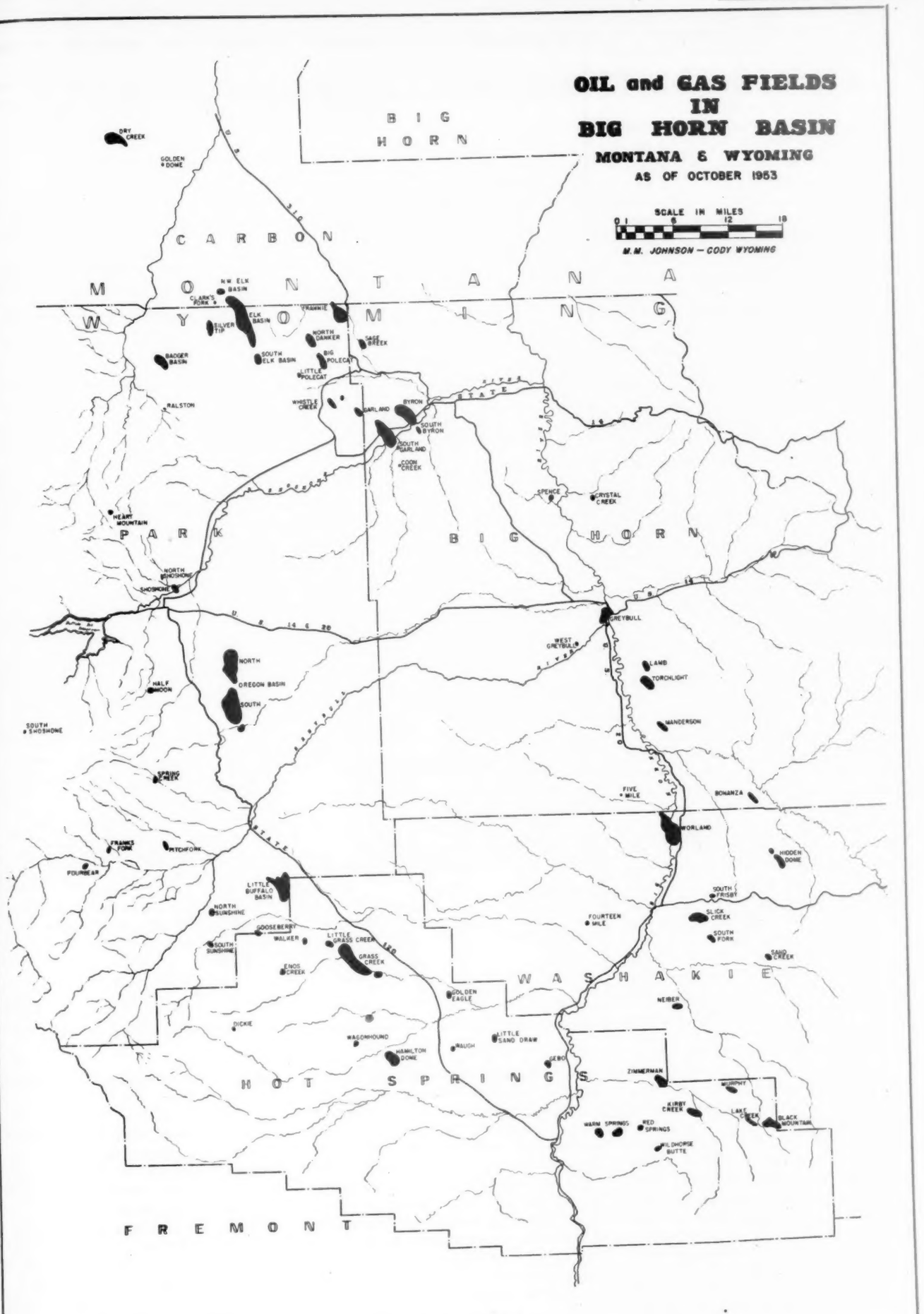
Permanent settlers began to arrive in the Basin in significant numbers in the 1890's. By this time a reasonably good road has been established over the Bridger Mountains from the south. The route of the road was, in part, along the Nowood River. An oil seep existed at that time near the early day village of Bonanza. The early wagon road passed near the seep in order that the travelers might secure grease for their wagons. This seep was said to have been discovered in 1884 and the first well drilled in the Basin was drilled near this seep in 1888.

Col. William F. Cody is said to have arrived in the Basin in about 1895. It was he and the early Mormon settlers who established irrigation projects. To a large degree, the region depends upon this irrigation for a major portion of their economy.

Oil was discovered in the Big Horn Basin at Garland, Big Horn County, Wyoming, in 1906. From this date on, the oil and gas business of the region has progressed more or less continuously, with no recession in sight.

Geology

So far as we now know, the first geologist to visit the Basin was G. H. Eldredge in the 1890's. His was the first geologic map. The very able N. H. Darton published his professional paper concerning the Big Horn Mountains in 1906 (USGS Prof. Paper 51). Soon other able geologists followed and in 1916 C. T. Lupton first published concerning oil and gas in the Basin (USGS Bull. 621). Again in 1917 Lupton published USGS Bull. 656, which was for years the oil man's "bible" for the region. Since these earlier workers much geological work has been done largely by the oil companies and so far their efforts have not been in vain. No attempt will be made to summarize this work; it is still in progress and will, no doubt, continue for years to come.


OIL and GAS FIELDS
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MONTANA & WYOMING
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SCALE IN MILES
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M.M. JOHNSON — CODY WYOMING
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CARBON
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WYOMING
PARK
BIG HORN
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FREMONT
DRY CREEK
GOLDEN DOME
CLARK'S FORK
NW. ELK BASIN
ELK BASIN
SILVER TIP
TRANNIE
NORTH DANKER
SAGE CREEK
BADGER BASIN
SOUTH ELK BASIN
BIG POLECAT
LITTLE POLECAT
RALSTON
WHISTLE CREEK
GARLAND
BYRON
SOUTH BYRON
SOUTH GARLAND
COON CREEK
SPENCE
CRYSTAL CREEK
HEART MOUNTAIN
NORTH SHOSHONE
SHOSHONE
GREYBULL
WEST GREYBULL
LAND
TORCHLIGHT
WANDERSON
NORTH OREGON BASIN
SOUTH OREGON BASIN
HALF MOON
SOUTH SHOSHONE
SPRING CREEK
FRANNIE
PITCHFORK
FOURBEAR
FIVE MILE
BONANZA
WORLAND
HIDDEN DOME
LITTLE BUFFALO BASIN
NORTH SUNSHINE
SOUTH SUNSHINE
GOOSEBERRY
WALKER
LITTLE GRASS CREEK
GRASS CREEK
ENOS CREEK
FOURTEEN MILE
SOUTH FRISBY
SLICK CREEK
SOUTH FORK
SAND CREEK
GOLDEN EAGLE
NEIBER
DICKIE
WAGONHOUND
HAMILTON DOME
WALCH
LITTLE SAND DRAW
GEBO
ZIMMERMAN
MURPHY
KIRBY CREEK
LAKE CREEK
BLACK MOUNTAIN
WARM SPRINGS
RED SPRINGS
WILDHORSE BUTTE

Big Horn Basin

Geologic History

No attempt will be made here to outline the complete geologic history of the region, but we shall note the main events in sketch form. Readers interested in more detail should read: "Tectonic Team-Research, Key to Social Progress and World Peace" by W. T. Thom, Jr., New York Academy of Sciences, January 7, 1952. Like all geologic history, we must begin in the pre-Cambrian. In the Big Horn Basin, during pre-Cambrian time there was much erosion and sedimentation followed by mountain uplifting and intrusion of plutonic rocks. No doubt that at some period during this very long interval of time, the fracture system of the basement was established. This fracture system is that which is now frequently referred to as the "Grain Lines" of the region; the major fault systems were generally established and the lines of weakness later to become mountain ranges, uplifts and downwarps were established.

Following the mountain uplifts of these early times, erosion took place, reducing the mountains to lowlands and providing sediments filling the early seas. The sea transgressed upon the land and active sedimentation began in the region of present interest. These areas of sedimentation are referred to as geosynclines. The Paleozoic geosyncline extended far beyond the area later to become the Big Horn Basin. During the long period of sedimentation in the Paleozoic Era, oftentimes shallows were formed in the epicontinental sea or islands appeared. In these shallows formed by minor vertical crustal movements, the sands were deposited later to become the oil reservoirs to be searched for by oil men. Later in geologic time crustal upward movements drained the seas and brought the region into erosion and into subaerial sedimentation. This took place in the local region during the Mesozoic Era and it was at this time that the giant reptile, the Dinosaurs, were developed and for a long period of time, they were "the rulers of the earth." The next in the sequence of main events was the retransgression of the sea. This time large thicknesses of sediments were accumulated, during Cretaceous times. As we shall see later, many of our shallower oil and gas reservoirs were deposited during this period.

At, or near, the close of the Cretaceous, there began a time of major uplift and mountain forming. This event is entitled the "Laramide Revolution." Most of the mountains that we now see in the west were formed at this time. There followed a prolonged period of erosion, still going on, and following the Cretaceous, the Tertiary Era began. During the Tertiary, mammals were developed and late in Tertiary time, man appeared. During late Tertiary time, the Pleistocene, there occurred vast glaciation in North America, the so-called "ice age." It is interesting to note that the large continental glaciers flowing down from their source in the north did not cover Wyoming. The high plains of Wyoming, uplifted during the Laramide Revolution, were a barrier to the flowing ice, as they might be to water, and the ice turned to the east and flowed around the region. Glaciation in Wyoming was confined to the mountain, or Alpine type, glaciers. Many of these existed in the mountains bordering the Big Horn Basin.

During the Tertiary vulcanism took place on a wide scale in the western regions and it was during this time that the Yellowstone Park volcanics were erupted and deposition was of the lake and valley fill types.

During the Laramide Revolution and perhaps subsequent to it, the folding, faulting, and arching took place in which the present day oil man is primarily interested, for the "oil traps" were formed in the "Basins" of the west. The Big Horn Basin was formed

GENERALIZED STRATIGRAPHIC SECTION FOR BIGHORN BASIN

GEOLOGIC AGE		UNIT NAME	DESCRIPTION
CENOZOIC	TERTIARY	YELLOWSTONE PARK VOLCANICS	Pyroclastic breccias and basic lava flows
		WASATCH	Red and pink shales; gray shales and sandstone
		FORT UNION	Buff and gray sandstones, gray carbonaceous shales, coal beds
MESOZOIC	CRETACEOUS	LANCE	White, gray and brown sandstones, thin shales and little coal
		MEETEETSE	White to brown sandstones, thin gray sandy shales and thin coal seams
		MESAVERDE	Buff to yellow sandstones, gray carbonaceous shales, coal beds
		CODY	Gray shale, upper part sandy, lower part limy and concretionary, bentonite beds at intervals
		FRONTIER	Gray shales and lensing gray glauconitic sandstones
		MOWRY	Dark gray shale, weathers gray to brown, fish scales common
		THERMOPOLIS (MUDDY SAND)	Black shale, gray sandstone zone (Muddy) in medial part
		CLOVERLY	Gray-brown sandy shale (Rusty Beds), gray sc, variag shale, basal conglomerate
	JURASSIC	MORRISON	Gray to greenish sandstones and sandy shales; variag sh, Dino. fossils
		SUNDANCE	Gray sandstones and sandy shales; gray limestones; maroon shales; fossiliferous
		GYPSUM SPRINGS	Massive gypsum beds; pink and gray gypsiferous shales
	TRIASSIC	CHUGWATER	Red sandstones and sandy shales, occasional thin limestone bed
		DINWOODY "EMBAR"	Gray to greenish shale, often finely pyritic
PALEOZOIC	PERMIAN	PHOSPHORIA	Gray limestone, glauconitic in part, phosphatic in upper portion
	PENNSYLVANIAN	TENSLEEP	Massive and cross bedded sandstone
		AMSDEN	Gray charty limestone and red shale
	MISSISSIPPIAN	MADISON	Massive and bedded gray limestone, irregularly charty
		THREE FORKS	Gray limestone
	DEVONIAN	JEFFERSON	Brownish thin bedded limestone often crystalline
	ORDOVICIAN	BIGHORN	Gray massive dolomite with scattered quartz grains
	CAMBRIAN	GALLATIN	Reddish limestones, gray and green shales, gray limestone, flat pebble conglomerates, Graptolites near top, Trilobites throughout
		GROS VENTRE	Gray, green and purplish sandstones and sandy shales, Trilobites
		FLATHEAD	Gray and tan sandstones and thin green shales, arkosic at base
PRE—CAMBRIAN		BASEMENT COMPLEX	Brown schists and basic intrusions, intruded by pink and gray granites

1000 / 500 VERTICAL SCALE IN FEET / 0

FIELD NAME	LOCATION	DISC. DATE	DISCOVERED BY	PRINCIPAL PROD. FORMATION	DEPTH TO PAY	APPROX. INITIAL PROD.	TYPE TRAP	NO. WELLS	DEEPEST TEST	SURFACE ELEV.	INITIAL PROD.	GRAVITY	SWEET OR SOUR	DISC. PRESS.	PROD. ACRE	CLOSURE	PRODUCTION	RESERVES	DISPOSITION	PRINCIPAL MKT.
L. Badger Basin	57N.-101W. WYO.	1931	Gus Forsman	Frontier – Dakota	126	0	Fault–Anti	11	Madison	Fort Union	8375	49	Sweet	Surf.	500 Ac.	600 ±	2,000,000	2,000,000	Ref'g Locally	Williston B. S. G.
E. Big Polo Cat	57N.-98W. WYO.	1918	Independents	Frontier – Dakota	0	0	Fault–Anti	5	Dakota	Mesa Verde	2700	GAS	Sweet	Surf.	500A ±	300 ±			Piped to Billings	Mule Creek

DATA ON BIG HORN BASIN FIELDS

FIELD NAME	LOCATION	DISC. DATE	DISCOVERED BY	PRINCIPAL PROD. FORMATION	APPROX. DAILY PROD.	TYPE TRAP	NO. WELLS	DEEPEST FORM. TEST	SURFACE FORMATION	PROD. DEPTH	GRAVITY	SWEET SOUR	DISC. METHOD	PROD. AREA	CLOSURE	PRODUCTION	RESERVES	DISPOSITION OF	PRINCIPAL OPERATOR
1. Badger Basin	57N.–101W. WYO.	1931	Gus Forsman	Frontier – Dakota	125	Fault—Anti	11	Madison	Fort Union	6375	49	Sweet	Surf.	500 Ac.	600 ±	2,000,000	2,000,000	Ref'd Locally	Williston O. & G.
2. Big Pole Cat	57N. – 98W. Wyo.	1916	Independents	Frontier – Dakota	0	Fault – Anti	5	Dakota	Mesa Verde	2700	GAS	Sweet	Surf.	600A ±	300 ±			Piped to Billings	Mule Creek
3. Black Mountain	43N.–91 W. Wyo.	1923	Utah Oil Ref.Co.	Embar-Tensleep-Mad.	400	Fault – Anti	10	Madison	Frontier	3200	22.5 – 26	Sour	Surf.	400 Ac.	1500'	3,000,000	3,000,000	Piped to Casper	Texas Company
4. Bonanza	49N. – 91 W. Wyo.	1951	Bonanza Oil Co.	Tensleep	10,700	Fault – Anti	50	Madison	Thermopolis	2500	34.6	Sour	Surf.	660 Ac.	200'+	3,500,000	18,000,000	" " "	Various
5. Byron	56N.–96 & 97W Wyo.	1919	Byron Union	Tensleep	6,500	Fault – Anti	53	Tensleep	Cody	5500	26	Sour	Surf.	1800 Ac.	2000'	28,000,000	25,000,000	Piped to Lovell	Ohio Oil Company
6. Clark's Fork	9 S. – 22 E. Mont.	1950	British American	Dakota	20	Fault – Anti	1	Madison	Mesa Verde	7550	57.7	Sweet	Seis.	one well	300'±	Small		Not Regular	British American
7. Coon Creek	55N. – 97 W. Wyo.	1953	Geo. Greer et al	Frontier	20	Fault – Nose	2	Frontier	Lance	4612	44	Sweet	Seis.	40 Ac.		Small		Ref'd Locally	Greer
8. Corley	43N.–93 W. Wyo.	1946	Continental	Embar	0	Small Dome	0	Tensleep	Cody	4100	24	Sour	Seis.	40 Ac.	250'	38,790	Abandoned	Abandoned	Continental
9. Cottonwood	41N.–91 W. Wyo.	1953	Stanolind	Embar	0	Stratagraphic	1	Tensleep	Lance	7300	24.8	Sweet	Seis.		None	None			Stanolind Oil & Gas
10. Crystal Creek	54N.–93 W. Wyo.	1919	Independents	Tensleep	0	Anticline	0	Madison	Chugwater	800	Low	Sour	Surf.	?	500'	Very Small	Abandoned	Abandoned	
11. Dickey	45N.–101 W. Wyo.	1953	Stanolind	Embar	0	Anticline	1	Tensleep	Tertiary	6600	19	Sour	Seis.	?	?	None		New Completion	Stanolind Oil & Gas
12. Dry Creek	7S. – 21 E. Mont.	1930	Ohio Oil Company	Frontier – Dakota	150	Fault – Anti.	17	Madison	Cody	5500	Gas - Cond.	Sweet	Surf.	540 Ac.	1000'	3,000,000	1,500,000	Gas to Billings	Ohio Oil Company
13. Elk Basin	Wyoming & Montana	1915	Joe Cook	Frontier to Madison	28,000	Fault – Anti.	137	Madison	Cody	1200 to 5800	30 – 45	Both	Surf.	5000 Ac	2000'±	72,000,000	220,000,000	Pipe to Casper	Stanolind Oil & Gas
14. Enos Creek	46N.–100 W. Wyo.	1949	Ohio & Stanolind	Embar – Tensleep	150	Anticline	3	Madison	Mesa Verde	6400	26–27	Sour	Surf.	100A±	1000'	300,000	1,000,000	" " "	Ohio and Stanolind
15. Five Mile	49N. – 93 W. Wyo.	1951	Husky Oil Company	Embar	0	Fault – Anti	1	Madison	Wasatch	11,645	47 – Dist.	Sour	Seis.	one well	300'±	None	30 MMMCF	Not on production	Husky Oil Company
16. Four Bear	47 & 48N.–103W. Wyo.	1929	Honolulu Oil Co.	Embar to Madison	0	Anticline	4	Madison	Thermopolis	2900–3700	13.5	Sour	Surf.	120 Ac.	1000'	None	2,000,000	" " "	Honolulu Oil Company
17. Fourteen Mile	46N. – 94 W. Wyo.	1951	Gulf Oil Corp.	Embar	0	Anticline	1	Tensleep	Wasatch	12,910	45 – Dist.	Sour	Seis.	one well		None		" " "	Gulf Oil Corp
18. Frank's Fork	48N. –103W. Wyo.	1949	Taylor Oil Company	Embar – Tensleep	0	Small Anticline	0	Tensleep	Cody	4,100	Low	Sour	Surf.	None		None	Abandoned		
19. Frannie	58N. – 98 W. Wyo.	1928	Val Kirk	Tensleep – Madison	10,500	Fault – Anti.	122	Madison	Frontier	2,600	18 – 26	Sour	Surf.	1400 Ac.	2000'	28,000,000	25,000,000	Piped to Billings	Stanolind and Continental
20. Garland	55-56N.–97-98 W. Wyo.	1906	Allen Oil Company	Frontier to Madison	11,150	Fault – Anti.	87	Madison	Cody	600+	20 – 40	Both	Surf.	3000 Ac.	3000'	25,500,000	38,000,000	" " "	Ohio Oil Co. et al
21. Gebo	44N.–95 W. Wyo.	1942	Continental Oil Co.	Embar – Tensleep	2,500	Fault – Anti.	35	Big Horn	Cody	4,500	22 – 29	Sour	Surf.	700 Ac.	500'±	4,000,000	14,000,000	Piped to Casper	Continental Oil Company
22. Golden Dome	7 S. – 22 E. Mont.	1953	Carrol Kirk	Dakota	100	Fault - Dome	1	Lakota	Mesa Verde	5,854	54	Sweet	Surf.	one well	500'±	None		Ref'd Locally	Carrol Kirk
23. Golden Eagle	45N.–97 W. Wyo.	1918	Midwest	Mesa Verde - Tensleep	1,800	Fault – Dome	7	Tensleep	Lance	2250–9000	41–56	Both	Surf.	400 Ac.	500'±		5,000,000	Piped to Casper	Phillips Petroleum Co.
24. Gooseberry	47N.–100 W. Wyo.	1937	General Petroleum	Embar	350	Twin – Dome	5	Madison	Cody	5,600	23	Sour	Surf.	160 Ac.	1500'	600,000	2,000,000	" " "	General Petroleum
25. Grass Creek	46 N. – 98-99W Wyo.	1914	H. L. Valentine	Frontier to Tensleep	12,020	Fault – Anti	304	Tensleep	Cody	900–4000	24–45	Both	Surf.	4000A	2500'	46,000,000	45,000,000	" " "	Ohio Oil Co. etal
26. Greybull	52N. – 93 W. Wyo.	1907	Homer Lamb	Dakota	25	Small Dome	?	Cambrian	Frontier	800	48.5	Sweet	Surf.	100 Ac.	150'	400,000	Nil	Ref'd Locally	
27. Half Moon	51N.–102 W. Wyo.	1944	Husky Oil Company	Embar – Tensleep	150	Fault – Anti.	4	Madison	Mowry	3500	15	Sour	Surf.	320 Ac.	500'	500,000	500,000	" "	Husky Oil Company
28. Hamilton	44N. – 98 W. Wyo.	1918	Mr. Curtis	Curtis to Madison	9,800	Fault – Dome	104	Basement	Mowry	1200–3100	14 – 26	Sour	Surf.	1200 Ac.	2000'	28,000,000	32,000,000	" "	Empire and Argo
29. Heart Mountain	54N.–102 W. Wyo.	1948	Trigood Oil Company	Frontier	0	Fault – Dome	6	Mowry	Cody	2100	Gas	Sweet	Surf.	500 Ac.	500'±			Piped to Billings	Montana Power Co.
30. Hidden Dome	47-48N.–90-91W Wyo.	1917	Ohio Oil Company	Frontier – Tensleep	225	Anticline	5	Madison	Cody	1400–4500	20 – 42	Both	Surf.	160 Ac.	300'±	900,000	400,000	Piped to Casper	Ohio Oil Company
31. Kirby Creek	43N.–92 W. Wyo.	1918	Unknown	Frontier - Embar	975	Anticline	11	Tensleep	Cody	380–3500	40	Both	Surf.	300 Ac.	350'	300,000	700,000	" " "	Pacific Western
32. Lake Creek	43N.–91-92W Wyo.	1949	Barnsdall	Embar – Tensleep	900	Fault – Anti.	16	Tensleep	Frontier	2950–3500	22 – 31	Sour	Surf.	1000 Ac	1000'	1,200,000	5,000,000	" " "	Various
33. Lamb	51 N.–92–93W. Wyo.	1913	Unknown	Frontier to Madison	25	Dome	3	Madison	Cody	435–3800	24	Sour	Surf.	160 Ac.	100'	150,000	100,000	" " "	Pond
34. Little Buffalo Basin	47-48N.–100W. Wyo.	1914	Ohio Oil Company	Frontier to Tensleep	3400	Twin Dome	29	Three Fork	Cody	1150–4800	20	Sour	Surf.	1400 Ac	1500'	7,600,000	30,000,000	" " "	Stanolind Oil & Gas
35. Little Grass Creek	46N.–99 W. Wyo.	1917		Frontier	0	Dome	1	Tensleep	Cody	2900	Gas	Sweet	Surf.	100 Ac.	500'			Piped Locally	Ohio Oil Company
36. Little Pole Cat	57N.–98 W. Wyo.	1922		Frontier	0	Fault – Anti.	1	Tensleep	Cody	4200	Gas	Sweet	Surf.	80 Ac.	250'±			Piped to Billings	" " "
37. Little Sand Draw	44N.–96 W. Wyo.	1949	Seaboard Oil Co.	Embar – Tensleep	500	Fault Dome	8	Tensleep	Cody	5830–6050	34–38	Sour	Surf.	240 Ac.	400'	1,500,000	2,000,000	Piped to Casper	Husky Oil Company
38. Manderson	50N.–92 W. Wyo.	1951	General Petroleum	Embar	0	Fault – Anti.	10	Tensleep	Mesa Verde	7220	37	Sour	Surf.	1200 Ac.	600'±	150,000	25,000,000	None Produced	General Petroleum et al
39. Murphy	43N.–91-92 W. Wyo.	1949	Farmer Union	Tensleep	1600	Dome	9	Tensleep	Cody	4364	34	Sour	Surf.	360 Ac.	300'±	1,100,000	7,000,000	Piped to Casper	Farmers Union
40. Neiber	45N.–92-93W. Wyo.	1947	G and G Drilling Co.	Embar	200	Anticline	3	Madison	Fort Union	10,025	42	Sour	Surf.	500 Ac.	500'+			" " "	California Company
41. North Danker	57N.–98 W. Wyo.	1948	Continental Oil Co	Frontier	0	Fault – Nose	1	Madison	Meeteetse	2,810	Gas	Sweet	Seis.	one well				Piped to Billings	Continental Oil Co.
42. North Shoshone	53N. –101–102W Wyo.	1952	Fletcher Edwards	Frontier	0	Stratagraphic	2	Dakota	Cody	2,000	40	Sweet	Surf.	40 Ac.		Small		None Sold	Esperado
43. North Sunshine	47N.–101 W. Wyo.	1928		Tensleep	0	Fault – Anti.	1	Tensleep	Frontier	3,486	15	Sour	Surf.	40 Ac.	1500'	"	500,000	" "	Continental Oil Co.
44. Northwest Elk Basin	9 S. – 23E. Mont.	1947	Sinclair	Frontier to Madison	150	Fault – Nose	11	Madison	Mesa Verde	3300–6400	28–52	Both	Seis.	200 Ac.	300'±	700,000	2,000,000	Piped to Casper	Sinclair
45. Oregon Basin	50-51-52N.–100W Wyo.	1912	Enalpac Oil & Gas Co.	Dakota to Madison	15,000	Twin Dome	191	Basement	Frontier	1200–4500	18–23	Sour	Surf.	8500 Ac	1500'	58,000,000	102,000,000	" " "	Ohio Oil Co. et al
46. Pitchfork	48N.–102 W Wyo.	1930	Honolulu Oil Co.	Embar – Tensleep	600	Fault – Anti.	7	Madison	Mowry	3,350	19	Sour	Surf.	200 Ac	2000'	1,500,000	1,500,000	Ref'd Locally	Husky Oil Company
47. Ralston	56N.–101 W Wyo.	1953	Sun Oil Company	Frontier	0	Anticline	1	Dakota	Wasatch	10,021	49	Sweet	Seis.	one well		None		Marketed Locally	Sun Oil Company
48. Red Springs	43N.–93 W. Wyo.	1919	Crosby	Madison	0	Dome	1	Madison	Embar	902	8	Sour	Surf.	40 Ac±	500'±	13,000	50,000	Not Marketed	Bales
49. Sage Creek	57N.–97 W. Wyo.	1948	Sohio & Barnsdall	Madison	200	Fault Trap	7	Madison	Cody	3,228	18	Sour	Surf.	200 Ac±	300'	60,000	100,000	Piped to Billings	Sohio and Barnsdall
50. Sand Creek	46N.–91 W. Wyo.	1947	General Petroleum	Frontier	250	Twin Dome	15	Madison	Wasatch	6,700	45.5	Sweet	Seis.	560 Ac.	350'	1,300,000	3,000,000	Piped to Casper	General Petroleum
51. Shoshone	53N.–101 W. Wyo.	1912	Shoshone Oil Co.	Frontier to Tensleep	125	Fault—Anti.	5	Madison	Frontier	600–4300	19	Both	Surf.	200 Ac.	1000'	480,000	400,000	Ref'd Locally	Husky Oil Company
52. Silvertip	57-58N.–100W Wyo.	1948	Seaboard Oil Co.	Frontier to Tensleep	1100	Fault – Anti.	20	Madison	Fort Union	5940–9665	44–46	Both	Seis.	900 Ac.	450'	1,650,000	3,200,000	Piped to Casper	Seaboard Oil Co.
53. Slick Creek	46-47N.–92W. Wyo.	1950	General Petroleum	Embar	0	Anticline	6	Phosphoria	Wasatch	10,464	32	Sour	Seis.	3500 Ac	350'	Small	8,000,000	Not Prod. Reg.	General Petroleum
54. Spence	54N.–94 W. Wyo.	1935	Calif. Expln. Co.	Madison	0	Dome	0	Madison	Embar	455	12	Sour	Surf.	None	700'	27,000	20,000	Not Producing	
55. South Byron	55-56N.–96W. Wyo.	1950	Taylor Oil Company	Frontier	0	Fault – Nose	20	Madison	Mesa Verde	2,700	40	Sweet	Surf.	200 Ac.	300'±	220,000	200,000	Ref'd Locally	Various
56. South Elk Basin	57N.–99 W. Wyo.	1945	Continental Oil Co.	Frontier – Tensleep	2200	Fault – Dome	20	Madison	Q. Gravel	5100–6960	28–45	Both	Seis.	1000 Ac.	600'±	2,800,000	11,000,000	Piped to Casper	Continental Oil Co.
57. South Frisby	47N.–92 W. Wyo.	1949	General Petroleum	Embar	10	Dome	1	Phosphoria	Wasatch	10,575	32.5	Sour	Seis.	40 Ac.	150'±	22,000	20,000		General Petroleum
58. South Fork	46N.–92 W. Wyo.	1947	General Petroleum	Embar	100	Anticline	2	Madison	Wasatch	10,070	29	Sour	Seis.	160 Ac.	350'	380,000	175,000	Piped to Casper	General Petroleum
59. South Garland	55N.–97 W. Wyo.	1950	M. D. Smith	Frontier	0	Fault – Nose	1	Tensleep	Mesa Verde	3,227	40±	Sweet	Surf.	20 Ac.		2,000	10,000	Ref'd Locally	M. D. Smith
60. South Shoshone	50N.–105W. Wyo.	1947	Continental Oil Co.	Embar	0	Anticline	1	Madison	Cody	3,705	18.1	Sour	Seis.					Not Producing	Continental Oil Co.
61. South Sunshine	46N.–101 W. Wyo.	1926	Continental Oil Co.	Embar	0	Fault – Anti.	1	Tensleep	Dakota	2,480	19	Sour	Surf.	40 Ac.	3500'	125,000	75,000	Ref'd Locally	Continental Oil Co.
62. Spring Creek	49N.–102 W. Wyo.	1930	Independents	Embar to Madison	500	Fault – Anti.	4	Madison	Frontier	3,657	15–19	Sour	Surf.	200 Ac.	2000'±	400,000	1,500,000	Ref'd Locally	Texaco-Pac. Western
63. Torchlight	51 N.–92–93W. Wyo.	1913		Frontier to Madison	500	Dome	14	Madison	Frontier	3900–3600	35–40	Both	Surf.	700 Ac.	400'	2,000,000	5,200,000	Piped to Casper	Stanolind Oil and Gas
64. Wagonhound	44N.–98 W. Wyo.	1944	Broderick & Gordon	Embar	25	Dome	2	Tensleep	Cody	4,300	30	Sour	Surf.	60 Ac.	600'	350,000	100,000	Ref'd Locally	Trigood Oil Co.
65. Walker Dome	46N.–99 W. Wyo.	1934	Ohio Oil Company	Dakota – Embar	25	Dome	1	Tensleep	Cody	3130–6590	20	Sweet Gas Sour Oil	Surf.	40 Ac.	300'±	Gas Only		No Oil Produced	Ohio and Forest Oil
66. Warm Springs	43N.–93-94W. Wyo.	1916	Shaffer	Embar	20	Twin Dome	10	Madison	Chugwater	960	20	Sour	Surf.	100 Ac.	150'	750,000	100,000	Ref'd Locally	Various
67. Waugh	44N.–96-97W. Wyo.	1934	Calif. Exploration Co.	Embar	75	Fault – Anti.	3	Madison	Cody	3,900	28	Sour	Surf.	80 Ac.	700'	600,000	200,000	" "	Husky Oil Company
68. West Greybull	52N.–94 W. Wyo.	1951	Trigood Oil Co.	Dakota	20	Fault – Anti.	1	Tensleep	Wasatch	10,360	Gas Dist.	Sweet	Seis.	40 Ac.	500'±			Gas to Montana	Trigood Oil Company
69. Whistle Creek	56N.–98 W. Wyo.	1951	Seaboard Oil Co.	Tensleep	125	Fault Trap	6	Madison	Mesa Verde	5,800	28	Sweet	Seis.	200 Ac.	300'±			Piped to Lovell	Seaboard Oil Co.
70. Wildhorse Butte	42N.–93 W. Wyo.	1948	Barney Cockburn	Embar	0	Anticline	3	Tensleep	Chugwater	1,094	14	Sour	Surf.	40 Ac.	100'±	Small	Small	Ref'd Locally	Barney Cockburn
71. Worland	48N.–92-92½–93 W. Wyo.	1946	Pure Oil Company	Frontier – Embar	3800	Fault – Anti.	30	Madison	Wasatch	7700–10000	20–44	Both	Seis.	6500 Ac	900'	11,500,000	20,000,000	Piped to Casper	Pure Oil Company
72. Zimmerman	44N.–93W. Wyo.	1945	Pacific Western	Embar	100	Anticline	6	Madison	Cody	4,300	25	Sour	Surf.	200 Ac	300'	840,000	750,000	" " "	Pacific Western
																	567,100,000		

at this time, is in fact a large syncline, and within it many folds and faults of diverse types.

Structural Geology

The Big Horn Basin is a structural depression, a syncline as mentioned above. The reader is referred to a United States Geological Survey "Oil and Gas Investigations Preliminary Map No. 74," a structure contour map of the basin. The structure of the margins of the Basin are clearly shown. It is to be noted that the Basin is almost entirely rimmed by anticlinal folding on a fairly large scale. Many of these folds are now producing oil or gas fields. The central portion of the Basin is not contoured on this map. It is even now not sufficiently understood to enable proper contouring. There is no doubt that anticlinal and synclinal folding exists in the central part of the Basin and it will be better understood in time for the geophysicists are at work on it.

Faulting is common in this region. There are several fault systems. Generally faults seen at the surface in the younger rocks strike at approximate right angles to the mountain ranges, most of these have relatively low order displacements. Faults exist not ordinarily seen at the surface. These are both the normal and thrust types and in general, these sub-surface fault systems strike parallel to the bordering mountains. In the mountains some of these may be examined. Thrusting is not in a single direction, but is, as a rule, away from the center of the basin, toward the mountain ranges.

Thus along the eastern margin of the Big Horn Basin, near or on the westerly slope of the Big Horn Range, one would expect thrusting to be from the westerly to easterly and likewise for the ranges along the other sides. This generalization is not infallible and in some local areas thrusting is in both directions, with one thrust sometimes cutting another. Folding, of economic interest to oil people, is of the anticlinal, domal and monoclinal types. Most of the big anticlines have been drilled and several major oil pools have resulted. The smaller types of traps are now being explored.

Stratigraphic Geology

A generalized stratigraphic section is presented herewith. It will be noted that all the geologic ages are represented except the Silurian. It is not present anywhere so far as we now know. There is considerable doubt that it was present and it is interesting to note that the Devonian is represented by very thin sediments and these are absent over a large part of the Big Horn region. No detailed discussion of the stratigraphy is considered necessary. The strata of economic importance will be discussed briefly in connection with the dissertation concerning the oil fields.

Economy Geology

In the present instance, we are primarily concerned with the oil and gas and associated substances. In addition to these, the Big Horn Basin has significant deposits of coal, bentonite, limestone, sulfur and gravels. The region is notably lacking in metallic substances.

Oil and Gas

As previously noted, oil was first produced in the Big Horn Basin at Garland in 1906. Since that time the more than 70 fields have been drilled and to date have produced over 341,000,000 bbl of oil. Many of the fields are small, but some are definitely of major proportions. Elk Basin, with 72,000,000 bbl production and 220,000,000 bbl of reserve and horizons known to be productive elsewhere remain to be drilled, would rank high as a producing field in any region.

Data concerning the numerous oil and gas fields are presented in tabular form. To present all these facts otherwise would be difficult and cumbersome. The fields are presented alphabetically and all pertinent facts are provided in suitable columns. Of a necessity, some of the facts are somewhat generalized. Amount of structural closure is approximated, for in a number of cases, total closure on the producing horizon is not known. Big Horn Basin folds commonly show increased closure with depth. A fold with a few hundred feet of closure at the surface, measured on young beds, may have two to three times as much closure at a depth of several thousand feet. The figures showing total production are close approximations in many instances and the reserve figures are those of the author entirely, and will not necessarily be the same figures if derived by another worker. In the case of the date of discovery, that date is shown for the first discovery of oil or gas.

The number of producing wells shown is that number capable of commercial production at the present time, whether actually producing or not. In this case it may be found that some old shallow wells are producing that were not included in the tabulation; for example, in fields such as Elk Basin and Grass Creek many wells produce from the Frontier and some of these may have been overlooked. Over 1400 wells are productive in the Basin and these are currently producing something like 130,000 bbl per day for an average of slightly over 90 bbl per day per well and some of these wells were drilled over 30 years ago. In the case of the daily production, the reader's attention is called to the fact that only oil is listed—gas production is omitted.

Oil is moved from the Big Horn Basin by pipe line to Billings, Montana, to Casper, Wyoming, to Wood-river, Illinois, and to other refining centers, in addition to that processed by local refineries. Gas is piped to Billings and to points in Eastern Montana.

Exploration Methods

A glance at the statistical chart will show that of the many fields discovered in the Big Horn Basin, most were discovered by surface methods. Of the 71 discoveries, 52 were by surface work alone and 19 by seismic. In most of the cases, the seismic work was preceeded and aided by surface work. In recent years the seismograph has become an important discovery tool in this area and will, no doubt, increase in importance with time. It is doubtful that surface work alone will result in additional discoveries, but it seems almost certain that seismograph and other geophysical tools will find more large reserves in this Basin. In addition to the seismograph, the gravity meter, magnetometer, and core drill have been used and have contributed in some measure to exploration successes in recent years. It is worth noting that the structural trap now productive is mostly of the anticlinal type, frequently faulted. Only two areas, neither as yet actually producing are thought to be wholly stratigraphic although the strat trap definitely contributes to the accumulation in others.

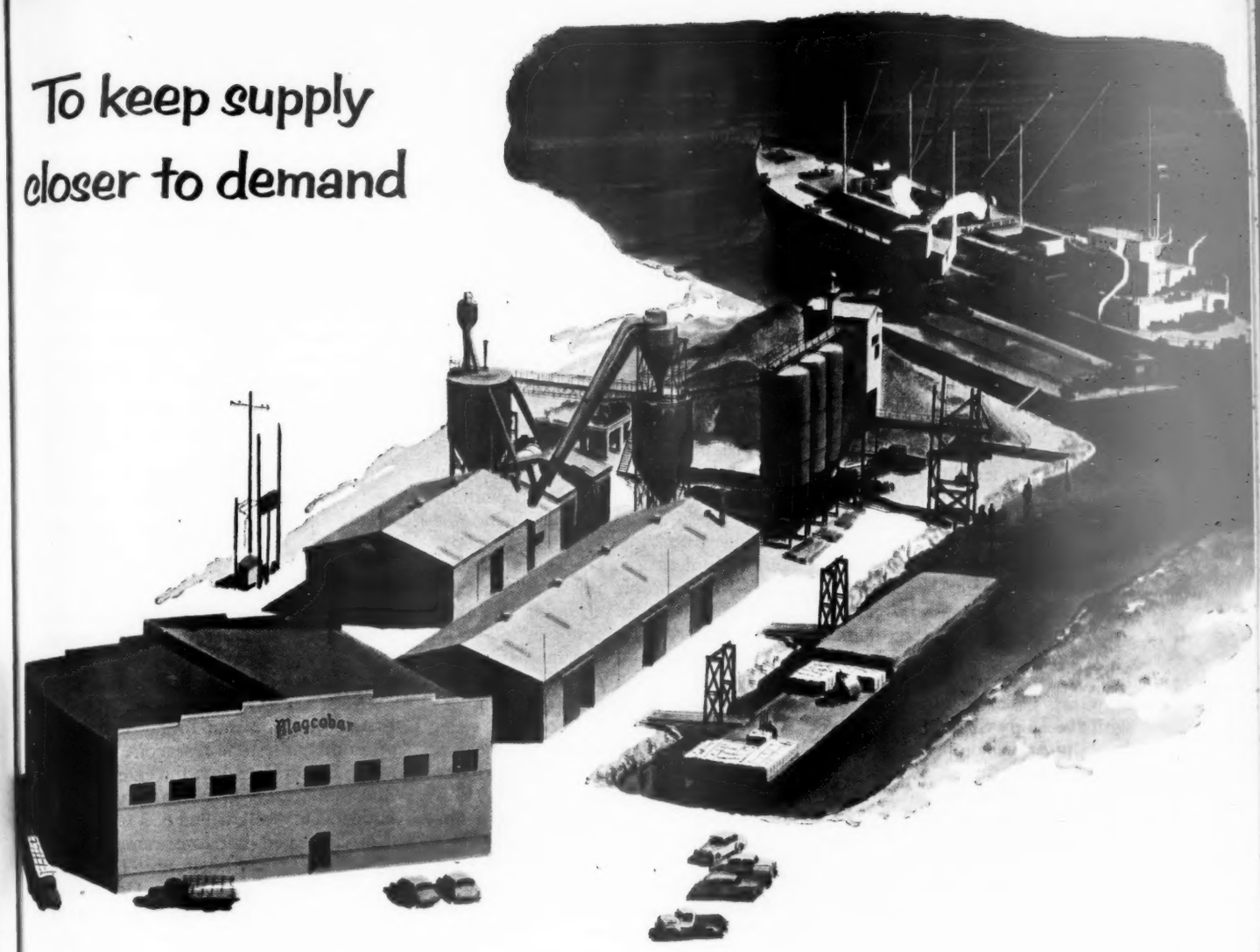
It is also worthy of note that in but two of the producing fields the drill has penètrated to the basement—Hamilton Dome and Oregon Basin. Others will be drilled to basement and additional deeper reserves will be found in many instances.

Sulfur Gases

In a number of instances, hydrogen sulfide gas occurs with the hydrocarbon gases and is produced with them. In the Worland field, the hydrogen sulfide content of the gas ranges up to 42 per cent and in other areas the H_2S varies from a few per cent to 30 per cent. The Texas Gulf Sulfur Company has a large sulfur extraction plant at Worland and Stanolind operates a smaller one at Elk Basin. Sulfur gases are found only in the Paleozoic beds, notably in the Embar and Tensleep formations, with lesser amounts in the Madison. Persons interested in this phase of the business are advised to consult with J. R. Fanshawe of Billings, Montana, a specialist in this regard.

Natural gasoline plants are not common in this area. There are but two, Stanolind operates one at Elk Basin

To keep supply closer to demand



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with a capacity of 1333 bbl of liquid per day and Pure Oil Company operates one at Worland, with a capacity of 1303 bbl per day.

Outstanding Oil Fields

In order that we may better understand the oil business in the Big Horn Basin we shall discuss, briefly, three of the most outstanding of the fields: Grass Creek, Elk Basin, and Oregon Basin. To discuss each of the fields in the area would be informative and interesting, but would make a paper entirely too long. It might be well to discuss one typical field and let this discussion more or less apply to all fields. This is not possible, for none of the fields is considered to be typical.

Grass Creek. The Grass Creek oil field is in T. 46 N., Rgs. 98 and 99 W., Hot Springs County, Wyoming, along the Western rim of the Big Horn Basin. The Anticline is crescent shape and is asymmetric with a northeasterly gentle flank and a southwesterly steep flank. The steep flank is faulted normally, with the field on the upthrown side of the fault. Grass Creek is a topographic basin with the Cody Shale on the surface and almost a complete escarpment of rim rocks of the Mesaverde formation surrounding the basin. The elevation of the basin is 5600 ft, and that of the escarpment is about 6000 ft; this rim is cut by two narrow notches, these having been cut by streams, through which the roads pass to the field.

The Grass Creek field was discovered in 1914. The discovery well was drilled in Sec. 18, T. 46 N., R. 98 W., to the Frontier, at a depth of 900 ft, and a light 44 gravity crude was found. According to early workers in the area 23 wells were drilled prior to January 1, 1915, and all were capped awaiting the pipe line to Chatham Station on the Burlington Railroad, which was completed in July 1915. In September 1919, according to D. F. Hewett of the U. S. Geological Survey, there were 332 producing wells. For many years, Grass Creek was the second largest producer in the entire Rocky Mountain Region, its production was exceeded only by Salt Creek.

A deep well was drilled in Sec. 19, T. 46 N., R. 98 W., in 1922 and found black oil of 24 gravity in the Embar and Tensleep formations. Since that time drilling of the Embar and Tensleep has progressed slowly. At about this time a well was completed in an upper sand in the Chugwater Red Beds by the Ohio Oil Company. This well produced almost unnoticed for many years. The producing sand in the Triassic has been named the "Curtis sand" by local operators. A similar sand had produced oil at Hamilton Dome to the south and was drilled by an operator named Curtis — hence the title "Curtis sand." In December 1949, Husky Oil Company completed their Kinney-Coastal No. 2 in this sand and subsequently drilled several more wells to the same horizon. At the present time there is a very active drilling campaign in progress, drilling the Curtis locations. This horizon has a productive area much larger than the Paleozoic members and will produce a considerable volume of oil. It is interesting to note that this Curtis sand production is the largest Triassic production in the world. The Triassic is currently capable of producing 12,000 bbl per day; however, due to limited pipe line capacity, the production from the horizon is restricted to about 6750 bbl per day, from a total of 92 wells now on production.

At the present time production is coming from the Frontier, Muddy, Curtis, Embar, and Tensleep. The Embar and Curtis are now the principal producers, but the Frontier has produced the largest amount of oil.

At this time there remains 171 of the original Frontier wells producing a total of 720 bbl per day. The Embar-Tensleep is produced from 41 wells and runs from these currently amounts to 4550 bbl per day. The structure has not been drilled below the Tensleep and it may be said that the Mississippian Madison, the Ordovician Big Horn and Cambrian offer possibilities for production not yet tested.

Working interest owners in the Grass Creek field are: Ohio Oil Company, Stanolind Oil and Gas Company, British-American Oil Producing Company, Brinkerhoff Drilling Company, Pacific Western Oil Corporation, Husky Oil Company, Lion Oil Company, Sinclair Oil and Gas Company, R. L. Manning, Argo Oil Company, and others.

Elk Basin. The Elk Basin oil field is in Ts. 57 and 58 N., Rgs. 99 and 100 W., Park County, Wyoming, and T. 9 S., R. 23 E., Carbon County, Montana, in the northern part of the Big Horn Basin, about half way between the Beartooth Mountains on the west and the Pryor Mountains on the east and is on the more gentle eastern flank of the Big Horn Basin Syncline.

Oil was discovered in Elk Basin as a result of surface geologic work in 1915 by Joe Cook, Jim Hurst, and others. The discovery well was drilled in Sec. 30, T. 58 N., R. 99 W., and discovery was made in the First Frontier at a depth of 1335 ft. Gravity of the oil is 43. Subsquently, the second Frontier was drilled and found to be productive. There are 99 Frontier wells and the Second Frontier produced most of the oil from this formation. Total Frontier production has been approximately 13,000,000 bbl and the formation is still producing.

In 1922 gas was discovered in the Dakota at a depth of 2600 ft in Sec. 24, T. 58 N., R. 100 W. Four Dakota gas wells were drilled, having a total open flow capacity of 160,000,000 cu ft per day with a surface pressure of 925 lb.

January 8, 1943, Minnelusa Oil Company No. 1 Henderson, in Sec. 31, T. 58 N., R. 99 W., was completed for an initial production of 1200 bbl in 12 hours from the Tensleep. Gravity of this oil is 30 and it is sour crude. Subsequent drilling has established a productive area of 5000 acres with a productive relief of 1900 ft in the Embar-Tensleep. Depth to this producing zone ranges from 3900 ft to 6000 ft, with an effective pay thickness of 100 ft or more. The Embar-Tensleep is unitized and Stanolind is the operator. The reservoir energy is water drive of a delayed nature. Stanolind is repressuring the reservoir. The natural-gasoline plant and the sulfur plant referred to elsewhere in this paper is operated by Stanolind principally on the gases from the Tensleep.

In 1946 Stanolind drilled Unit No. 38-M in Sec. 24, T. 58 N., R. 100 W., to the Madison and found 30 gravity oil in this limestone reservoir. The well made 247 bbl per day, the extent of the Madison reservoir is not yet fully known. This well drilled 633 ft of Madison. Untested horizons remaining to be drilled in Elk Basin are: Devonian Jefferson, a dolomite, the Ordovician Big Horn, a dolomite, and the sands of the Cambrian.

Elk Basin has now produced over 72,000,000 bbl of oil and has a remaining reserve of 220,000,000 bbl with at least three untested horizons, and is now the largest producer in Wyoming and is exceeded in the entire Rocky Mountain region only by the Rangely field in Colorado. Of all the fields in Wyoming only Salt Creek will apparently produce more oil than the expected ultimate yield of Elk Basin.

Oregon Basin. Oregon Basin is located in Ts. 50, 51 and 52 N., Rge. 100 W., Park County, Wyoming. This field is a large topographic depression on the western side of the Big Horn Basin and is rimmed to a large extent by an escarpment of sandstones of the Mesaverde formation. Surface elevations in the Basin range from about 5200 ft to 6194 ft atop Elk Butte, a topographic prominence within the topographic basin. Elevations of the escarpment range from 5300 to 6300 ft.

Oregon Basin is in fact two distinct domes upon the north-south trending major axis of folding. These are two separate oil fields entitled North Dome and South Dome. The area is unitized below the top of the Triassic and the Oil Company is the operator — they operate four units: North Dome Embar-Tensleep Unit, North Dome Madi-

PAGES FROM THE LEBUS WIRE LINE SPOOLING HANDBOOK

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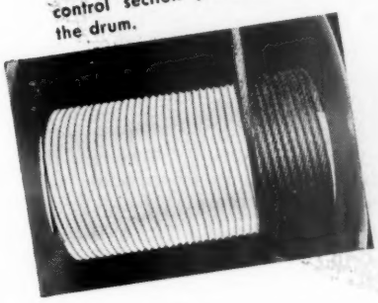

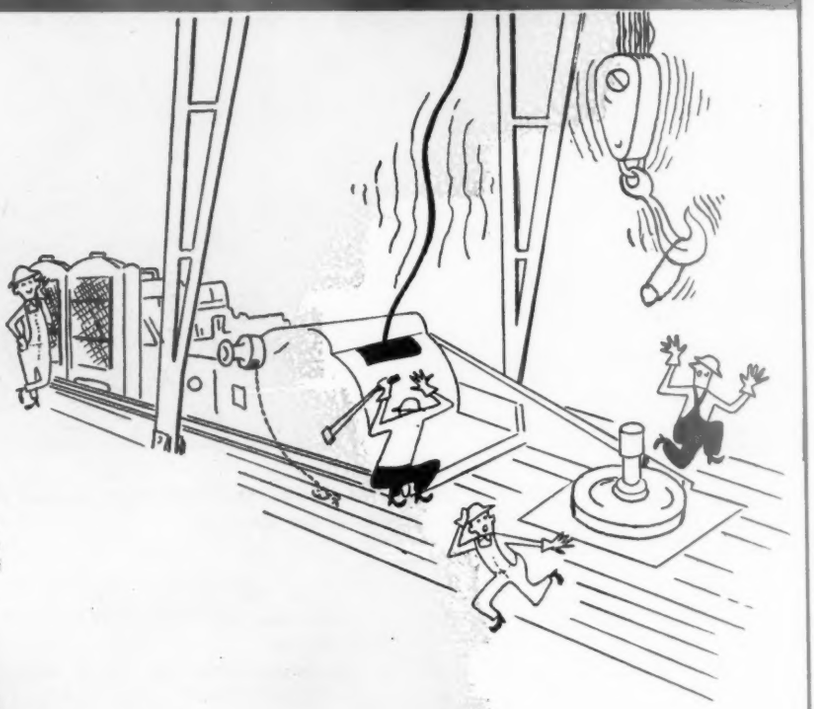

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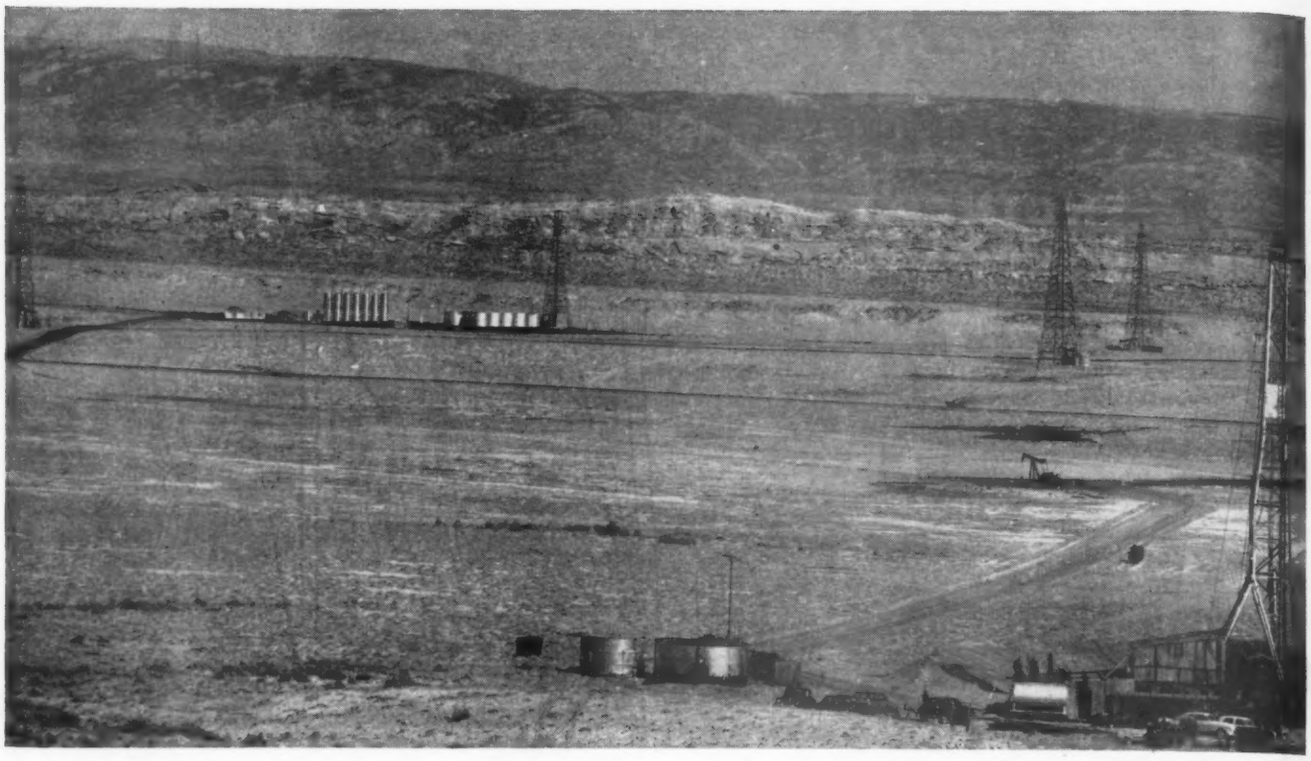

— *Jack Richards Photo.*

Oregon Basin showing drilling well in right foreground, producing wells, storage etc., looking west, escarpment of Mesaverde sandstones in the middle distance. Mountains in the distance.

son Unit, South Dome Embar-Tensleep Unit, and South Dome Madison Unit.

Oregon Basin was discovered by surface methods and the first well was drilled by the Enalpac Oil and Gas Company in 1912 with the discovery well on the South Dome flowing 20,000,000 cu ft of gas daily from the Dakota sand. In March 1927, a well drilled in Sec. 8, T. 51 N., R. 100 W., discovered 22 gravity oil in the Embar and Tensleep formations. This well had initial production of 800 bbl per day. Oil was discovered in the Madison in 1943 in Sec. 5, T. 50 N., R. 100 W. There is an upthrown fault block on the south end of the South Dome and gas is produced from the Frontier from this, as is oil from the Embar. In a number of wells recently drilled large gas reserves have been found in sands of Triassic age and the Ohio Oil Company will use this gas to repressure the Paleozoic reservoirs.

In 1945 Pacific Western Oil Corporation and others drilled a basement test in Sec. 29, T. 50 N., R. 100 W. No oil was found below the Madison in commercial volume, but at the Cambrian-Basement contact, there was a good showing of high gravity crude. The failure of this well to establish production in beds below the Madison does not necessarily disprove these lower formations for the entire field. This deep test is on the South Dome and a location can be had that would be at least 250 ft higher on structure and in addition to this, the North Dome has not been tested below the Madison.

Oregon Basin has a total structural closure of 1500 ft or more and a productive relief of 1125 ft. The North Dome has an independent closure of 700 ft and the South Dome has 900 ft.

To date the production from Oregon Basin has been about 58,000,000 bbl. This seems low for such a big field, but the oil is low in gravity and for many years oil was produced only when there was a market demand and this was erratic. In early years the crude was used as fuel for power by the Burlington Railroad at a price of 40 cents per barrel and this did not encourage production. At other times there was no market for this crude except the Husky Oil Company refinery at Cody. At the present time, the combined Oregon Basin production exceeds 15,000 bbl per day. This is as high as it has ever been and resulted from the recent connection to the Platte Pipe Line Company system.

Oregon Basin reserves are very conservatively estimated at 102,000,000 bbl as of this writing. Original stock tank oil has been estimated by engineers for the Ohio Oil Company at 540,000,000 bbl; the estimates, then, would indicate that approximately 30 per cent of the original oil will be produced. I think it safe to say that with improved techniques this may be increased materially, and at some future date, after a considerable additional production from Oregon Basin, the reserves may then be estimated as high or higher than those now given.

By discussing briefly but three of the oil fields in the Big Horn Basin, it is not intended to slight any of the others, for many of the remaining fields are as impressive as the three chosen when one considers the areas involved. The Big Horn Basin is the principal producing basin in Wyoming, but it is by no means the largest. Only those structures that were easy to find have been drilled, however, and there remains literally dozens of good prospects in this area yet to be tested by drilling.

Proration

There is no proration as such in Wyoming. In a number of cases, wells are voluntarily prorated to meet limited pipe line capacities. At the present time, the pipe line capacity for Grass Creek is inadequate to carry all the oil that the field is capable of producing and operators are cutting their production proportionately.

Acknowledgments

Special acknowledgment is due to Gene Marty, draftsman, for doing the illustrations for this paper and to Eldon House, district geologist of the Husky Oil Company, for assistance in preparation of the material presented. J. R. Fanshawe of Billings, Montana, gave advice and was the original author of the map presented herewith. * *

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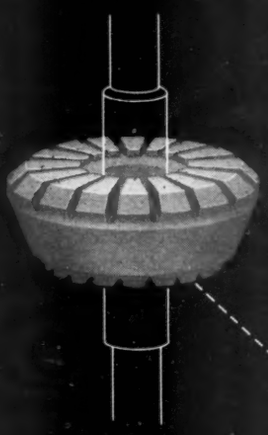

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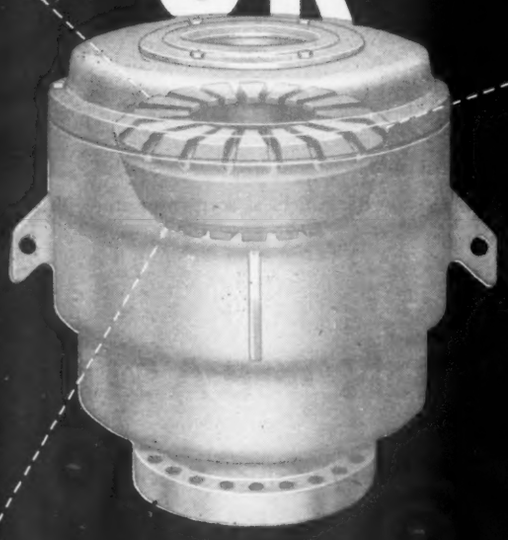

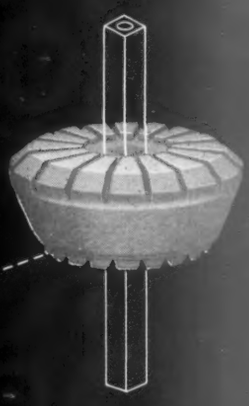

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North Oregon Basin field as seen from atop Elk Butte.

P 205

THE BIG HORN — BASIN OF BASINS

This Rocky Mountain petroleum province is becoming one of most important areas with both production and rate of discovery increasing rapidly

SIM H. CREWS*

THE bustling activity now so evident all over the Big Horn Basin offers small reminder of the relatively slow development experienced during the early days of its oil producing history. Probably the Bonanza field is as aptly illustrative of this trend as any in the area. Pioneers located an oil seep in the vicinity of this field and early trails were routed by this seep in order that wagon lubricant might be collected. A shallow and unsuccessful test in the vicinity was drilled before the turn of the century.

Then in 1951, sixty-five years after the first indications of oil in the area were noted, the Bonanza Oil Company completed the discovery well in the Tensleep formation at a depth of 2500 ft. The following three years saw the completion of 50 wells with the daily production climbing to more than 10,000 bbl. Bonanza has produced 3,500,000 bbl of oil and has a conservative reserve of another eighteen million barrels based on presently known horizons. That other productive zones may exist with subsequent enlargement of reserves is entirely possible. This possibility is demonstrated by a brief study of Grass Creek field.

*Editor, Drilling and Producing.

Grass Creek

Discovered in 1914, the prolific Grass Creek field first produced a very high quality, 44 deg crude from the Frontier sand of lower Cretaceous age encountered at 900 ft. Subsequent deeper drilling proved, in 1922, production in the Permian age Embar and the Upper Pennsylvanian Tensleep. At about the same time, a "sleeper" was completed in the Curtis sand member of the Triassic age Chugwater Red Beds. This latter well received little attention and produced alone in the reservoir until 1949 when a second Curtis sand well was completed and the present active development of the zone began. It has now become evident that this horizon, which lay unnoticed for so many years, is the largest in area of the field as presently defined and is the largest Triassic producing area known. There are now 92 Curtis producers and at least four rigs drilling Curtis wells.

Grass Creek is also an excellent example of the typical "Basin of Basins" peripheral geology of this area. A high percentage of the known fields resulted from drilling locations based on surface geology that is readily apparent around the rim of the egg-shaped basin. These topographic depressions are the direct result of erosion of the weakened surface over the anticlinal flexures responsible for the producing structure. Further surface evidence of these structures is seen in the Elk Basin and Oregon Basin fields.

Oregon Basin

The Oregon Basin, a major reserve, is really two separate domes on one anticlinal axis. Separate domal closures

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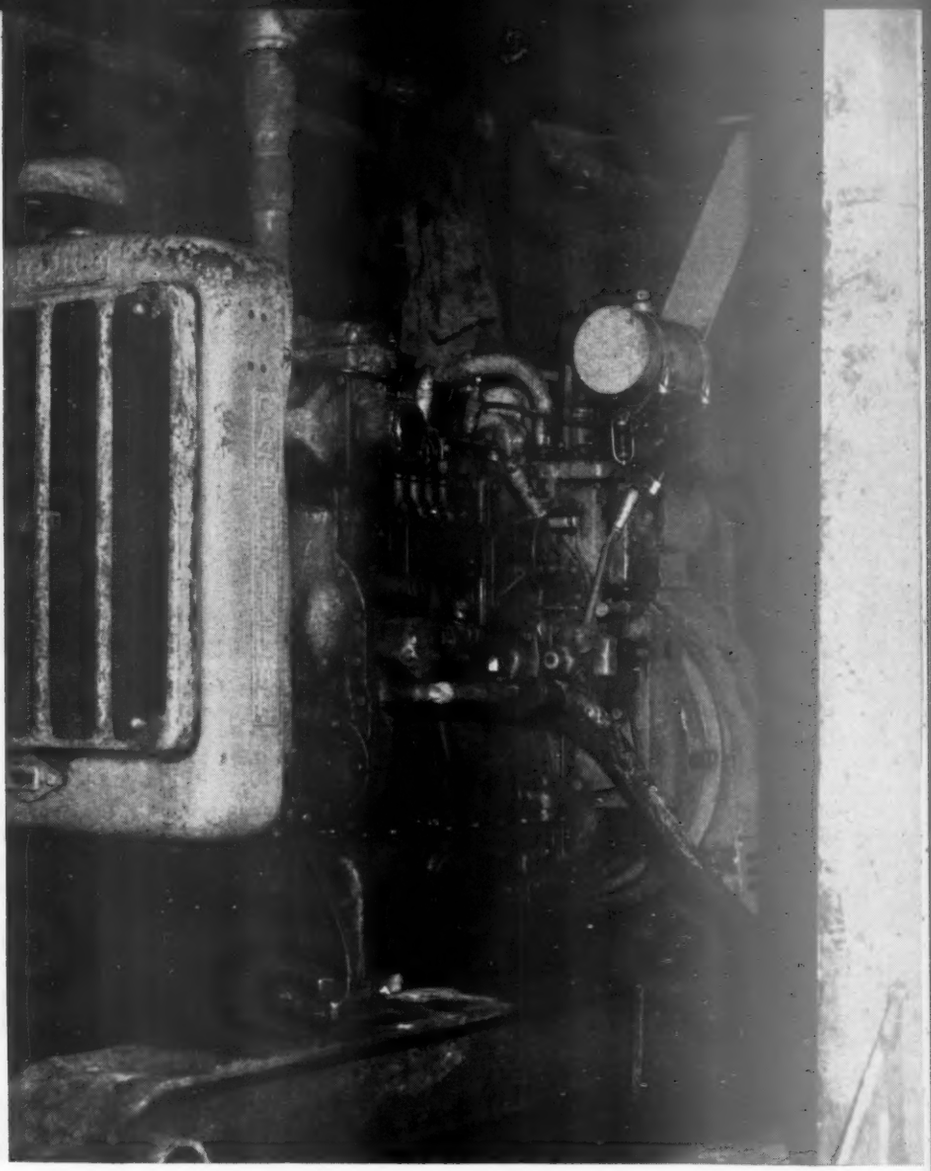

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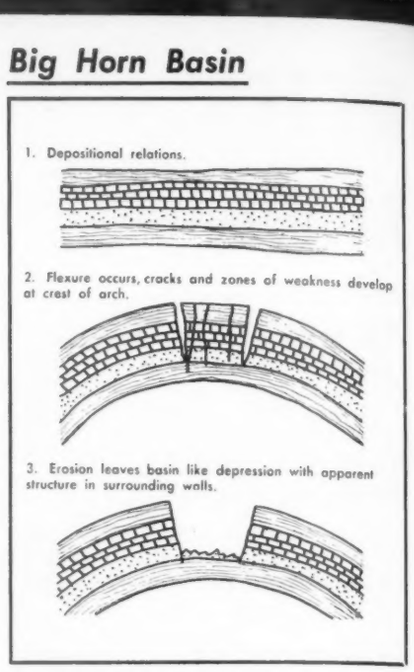
Ohio Oil rig in Grass Creek field. Rim of topographic basin extends completely around field. Evidence of domal structure is characteristically apparent.

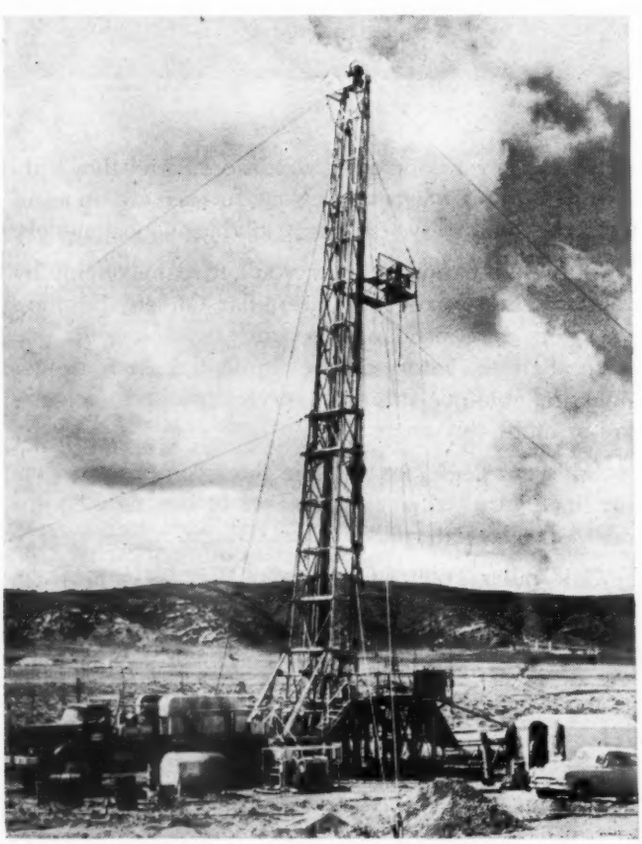

Big Horn Basin
1. Depositional relations.
2. Flexure occurs, cracks and zones of weakness develop at crest of arch.
3. Erosion leaves basin like depression with apparent structure in surrounding walls.

Simplified evolution of anticlinal structure.

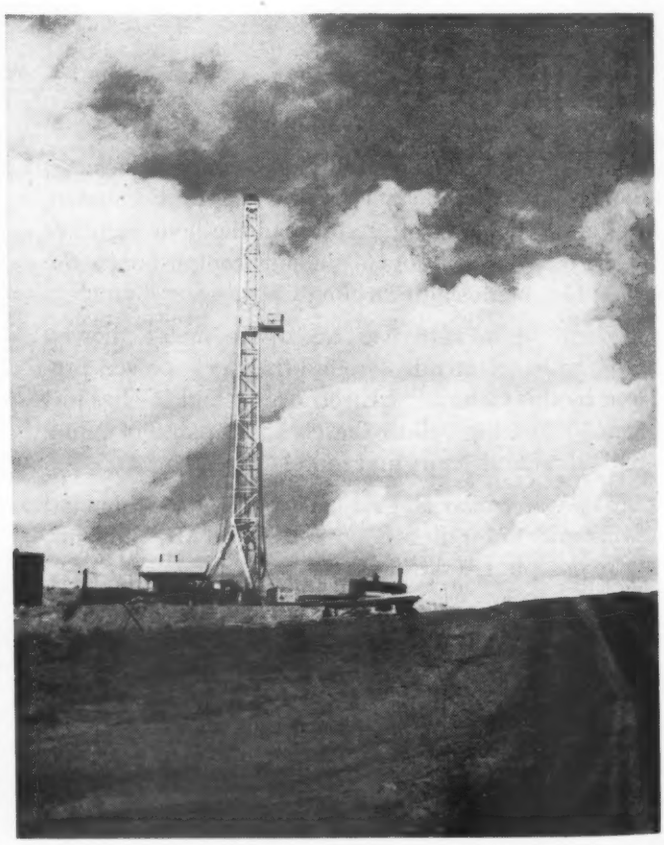
of 700 and 900 ft have been established with a total closure on the major fold of some 1500 ft. Now operated as a unitized field for the Embar-Tensleep and Madison horizons in both domes, pressure maintenance and production control should materially improve the ultimate recovery above the presently estimated hundred million barrel reserve. Unitization in the field has also materially reduced lifting costs and treating costs through consolidation of facilities and reduction of manpower requirements.

Stratigraphic Traps. Only two of the 70 known fields in the basin are the result of purely stratigraphic traps though there are many other fields at least partly stratigraphic in nature. One of the purely stratigraphic traps is produced in the Cottonwood field where the Tensleep zone was encountered at 7300 ft. This 1953 discovery has no production history at present nor can reliable reserves be estimated.

The second strat-trap is found in the North Shoshone field where two wells



Portable rotary drilling Curtis well in Grass Creek field. Note central power producing 900 ft Frontier sand in background.



Skyline view of jack-knife rig also drilling Curtis well in Grass Creek. Boiler provides heat in winter operations.

ABRASION

HEAVY IMPACT

CORROSION

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FOR EVERY WELL CONDITION

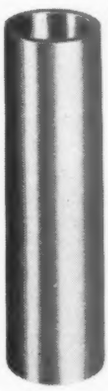
In case after case, reports from the field state Axelson liners, and particularly the DUAX, are extending pump operating life from 4 months to as much as 2 years between pull jobs due to liner failure. This is not happen-stance, of course. In the over 62 years of service to the Petroleum industry, Axelson has gathered a background of experience second to none. Metallurgical developments and production controls at Axelson provide liners specifically designed to withstand the three bugbears of liner wear—corrosion, abrasion and impact.

REGULAR CAST IRON liners are made of alloy gray iron and give excellent service under normal pumping conditions. High standard of material and workmanship is assured as liners are cast in Axelson's **own** foundry.

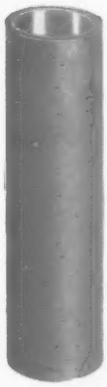
HARDENED CAST IRON liners are made of an alloy gray iron melted in an electric furnace and **centrifugally cast** in the Axelson foundry. The liners are hardened and tempered in automatically controlled electric furnaces, resulting in high strength, toughness and surface hardness.

DUAX liners are manufactured by a new process whereby specially alloyed iron, which is as hard as fine tool steel, is centrifugally cast into a seamless steel shell by a patented method which assures an absolute bond between the two metals. The extremely hard inner surface of the liner offers amazing wear-resistant properties, while the tough outer steel shell prevents any possibility of the liner cracking due to brittleness. To insure uniform quality throughout, each Duax liner is carefully checked by the Magnaflux method of magnetic inspection.

HARDENED CAST IRON



REGULAR CAST IRON



DUAX

RELATIVE MERITS OF THE DIFFERENT TYPES OF LINERS UNDER VARIOUS WELL CONDITIONS

ABRASION RESISTANCE	IMPACT RESISTANCE	CORROSION RESISTANCE	
		HYDROGEN SULPHIDE	SALT WATER
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Hard Iron	Hard Iron	Regular Iron	Hard Iron
Regular Iron	Regular Iron	Duax	Regular Iron

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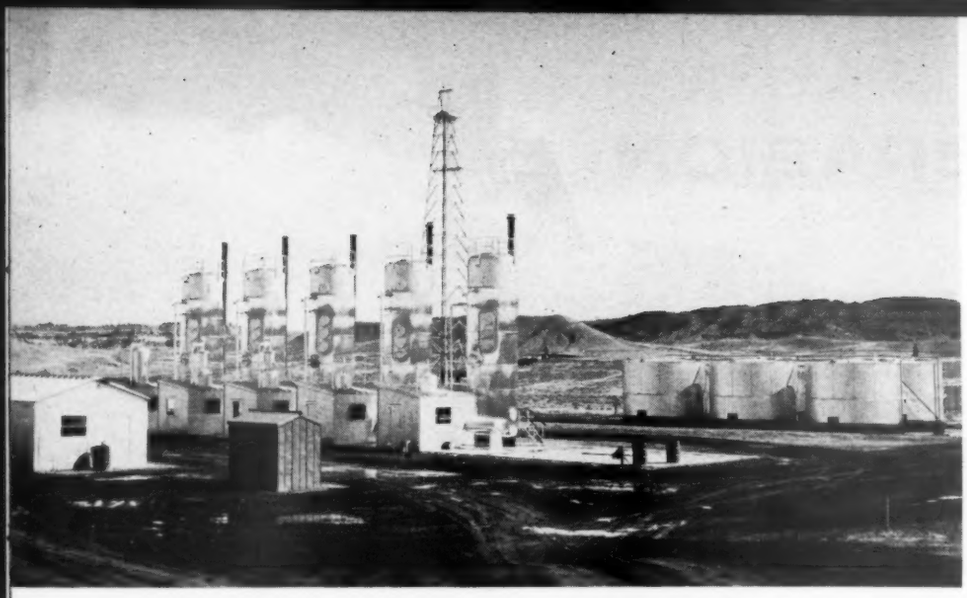
PR-8



Typical new tank battery in Oregon Basin constructed under the unitized operating agreement.

are completed but have not been produced since their discovery in 1952. Here also, reserves are indefinite though the Frontier sand, producing horizon for the field, is historically a good producer.

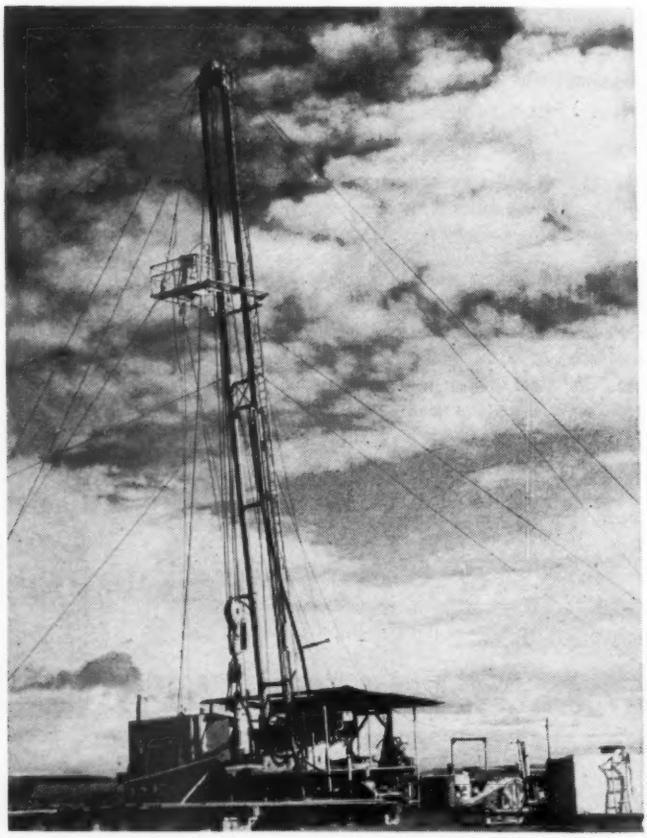
Certainly there is reason to believe that the area offers reasonable promise to the search for accumulations of this nature. One major operator at least is actively and intelligently entering the search with a "slim-hole" or core type rig now working along the eastern flank of the basin north of Worland. The success of this venture will undoubtedly encourage further operations of this nature and a study of the section predicts their probable success.

Pressure Maintenance and Repressuring. No discussion of the Basin would be complete without at least a brief reference to the matter of improved reservoir performance under modern production technique. An outstanding example of this is seen in current operations in the Elk Basin field

Big Horn Basin

at the northern end of the Big Horn Basin. Here, in one of the finest applications of true conservation, operators are repressuring the prolific Tensleep reservoir with nitrogen. There is a shortage of natural gas for injection to supplement the limited water drive in this reservoir and much of the available gas is sour. Faced with this problem, operators have installed a sulfur plant to remove hydrogen sulfide from produced gas. Residue gas then moves to a second plant, where liquid hydrocarbons are removed, and thence to sale. Gas consumed in the two processes is burned under conditions of carefully controlled combustion and the exhaust or flue gas is cleaned of undesirable elements, compressed, and injected into the reservoir. Not only do the operators realize salable sulfur, LPG, and natural gas through this process, they also end up with over nine volumes of injected nitrogen in the reservoir for each volume of sour gas consumed.

Pressure maintenance in the Oregon Basin field is underway and shows immediate promise. There is also an excellent program under way in the Steamboat Butte field, south of the Big Horn Basin but geologically related. Another future repressuring prospect will be seen in the 900 ft Frontier sand in Grass Creek. * * *



"Slim-hole" rig in operation near Worland. This unit is equipped to drill 4¾-in. hole and is complete with both conventional and diamond bits and diamond core head and barrel.

A search for stratigraphic traps is being conducted in this area northeast of Worland in the Eastern side of the Big Horn Basin.

Snowy peaks forecast winter's arrival at this Big Horn basin wildcat.

P 501

WINTER IN WYOMING

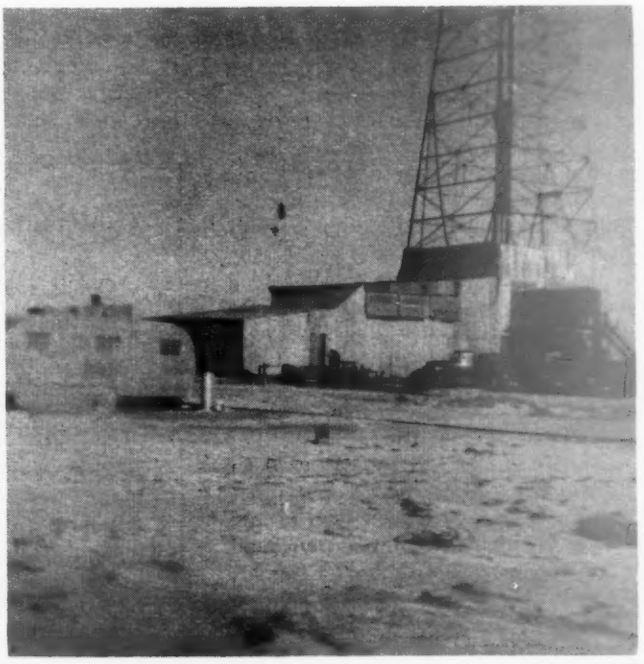
Surprisingly mild is Big Horn cold season. Operations continue on year round basis with little time loss and few hardships

JOHN R. YODER[1] and M. M. JOHNSON[2]

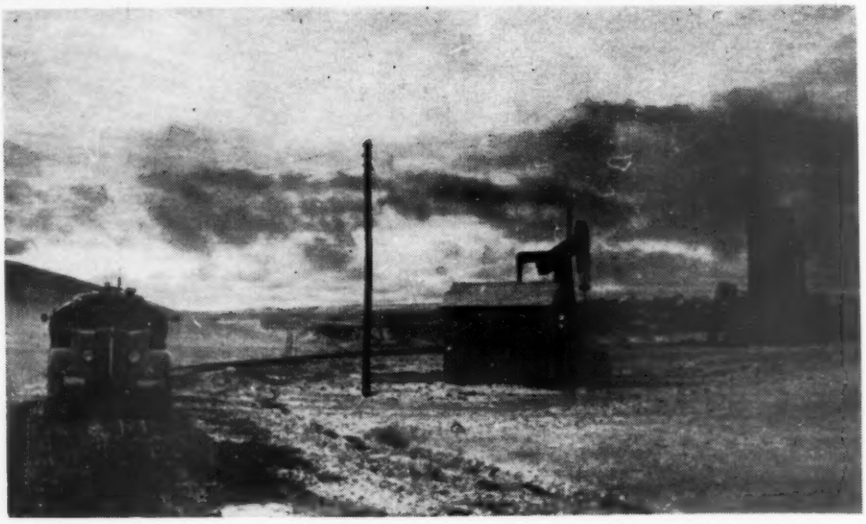
To those persons familiar with the area an article concerning winter operations in the Big Horn Basin will come as something of a surprise. To those not familiar with the region a few remarks on the winter work may well be of considerable interest. To the best knowledge of the authors, there are no operations that can be done in the summer that cannot be done in the winter. All drilling operations proceed throughout the winter with little if any loss of time due to weather or other winter conditions. Drilling rigs have to be enclosed for several feet above the derrick floor and the monkey board requires a wind break made of canvas or lumber. In addition to this a small boiler is usually employed with the drilling rig and steam is piped to the blowout preventers to prevent them from freezing, and sometimes the

[1]Production superintendent, Husky Oil Company, Cody, Wyoming.
[2]Consulting geologist, Cody, Wyoming.

EXCLUSIVE



With rig floor protected, cold has little effect on drilling operations. — *Courtesy Husky Oil Company.*



Courtesy Husky Oil Company.

PUMPING WELL, oil field treater and transport truck of winter operations are shown at Husky Oil Company Half Moon lease, Park County, Wyoming.

source of water requires some steam to keep it open at all times. Other than these relatively simple precautions, however, no extremely complicated or expensive rigging is required. Internal-combustion engines are almost invariably cooled with nothing but water in the coldest weather with their radiators generally equipped with automatic shutters to keep engine temperatures uniform. We know of no case where the mud system has frozen with the rig running; however, if the pumps were to be shut down for any considerable period of time in cold weather then the mud system would have to be either drained or heated in some manner. When it is very cold it is often necessary to pipe steam or hot water to the derrick floor to enable the crew to clean up after making a trip. It is rarely necessary to provide snow plow equipment to keep the roads open except perhaps to wildcat wells in the higher elevations. When this is required it is a general practice to open the roads with a bulldozer or road grader. Sometimes a truck equipped with a plow can do the job. Personnel working in the field of this region require some heavy clothing but overalls over ordinary work clothes are usually sufficient and satisfactory. Almost all hands wear heavy four-buckle arctics over ordinary shoes and everyone wears two pairs of work gloves in the winter. These things, plus a cap with earmuffs are adequate for our winter operations.

All automotive equipment used in the oil field work or for any other purpose must be supplied with proper antifreeze in the cooling system, and thus protected, frozen cooling systems are rare. Some persons make considerable preparation of their motorized equipment for winter operations, such as tire chains, tow cables, snow shovels, and such but they are rarely put to use. In addition to these things some people also carry emergency rations, emergency heating equipment (such as small gasoline stoves), emergency bedding such as sleeping bags, etc. These writers have lived in the Northern regions for more than 40 years and have never had need for any of these things except tire chains and shovel and these only rarely and generally on oil field or new and none too well improved roads.

We do not pretend that we have no winter in a region that lies at a latitude of 44 deg north and at an elevation of 4 to 7000 ft. It is a fact, however, that the winters in the Big Horn Basin are generally mild compared to other Northern regions and all work goes on continuously 365 days per year, if necessary.

The problem of additional cost naturally arises in the matter of considering winter work in the Big Horn Basin. It should be noted that contractors bid the same prices for winter work as they do for summer work although the winter operations are obviously a little more costly. The principal additional costs in drilling is the operation of one small boiler and as a rule this can be done for about 12 to 15 dollars per day and compared to the over all cost of rig operation that is not an important figure. In the production work winter costs are very little higher than those for any other season of the year. There is little to do to prepare a producing lease for winter. Flow lines from wells making water with the crude must be buried below the frost line, usually about 5 ft. If liquid cooled engines are in use the cooling system would require protection, but engines of this type are rarely used. Most production power is from air cooled engines or electric motors. Water supply to production camps is delivered through underground pipes buried below the frost line. Production departments have excellent housing facilities in several fields or close to them and heat is provided by gas from the fields. There is no discomfort to the workers or to their families.

Although oil treating costs are generally higher in this region all of this cost is not due to the cold weather. Lower gravity crudes and the absence of natural gas contribute to higher treating costs to a much greater degree than the low temperatures.

Most of the drilling and producing operations to date are below 6000 ft elevation. For those few operations carried on above this level and on up to 9000 ft the weather conditions become progressively more extreme.

Most of the oil fields are served by school buses transporting school age persons to the consolidated schools in the towns of the region. Persons interested in oil field operations in the Rocky Mountain region find the people in the Big Horn Basin working all of the year, refuting the myth of impossible winters. * * *

Continental Purchases Large Share Of Oil Properties in Bonanza Field

Continental Oil Company, currently producing oil in Wyoming, has bought a major interest in the Bonanza oil field of Big Horn County, Wyoming. Reports of the deal were confirmed by Continental recently, after rumors were heard in stock market and oil circles for some time.

Poppy Oil Company of Dallas made the sale, after recently acquiring the properties from General American Oil Company.

Purchased by Continental were approximately 950 net acres with 36 producing wells that have a daily production capacity of 9000 bbl. Wells on this purchased property are producing about 3500 bbl daily at this time.

Although price of sale was not reported, it was rumored that Poppy reserved oil payments of approximately $20,000,000. General American is said to have acquired the properties from Bonanza Oil Company for $20,500,000 in December of 1952.

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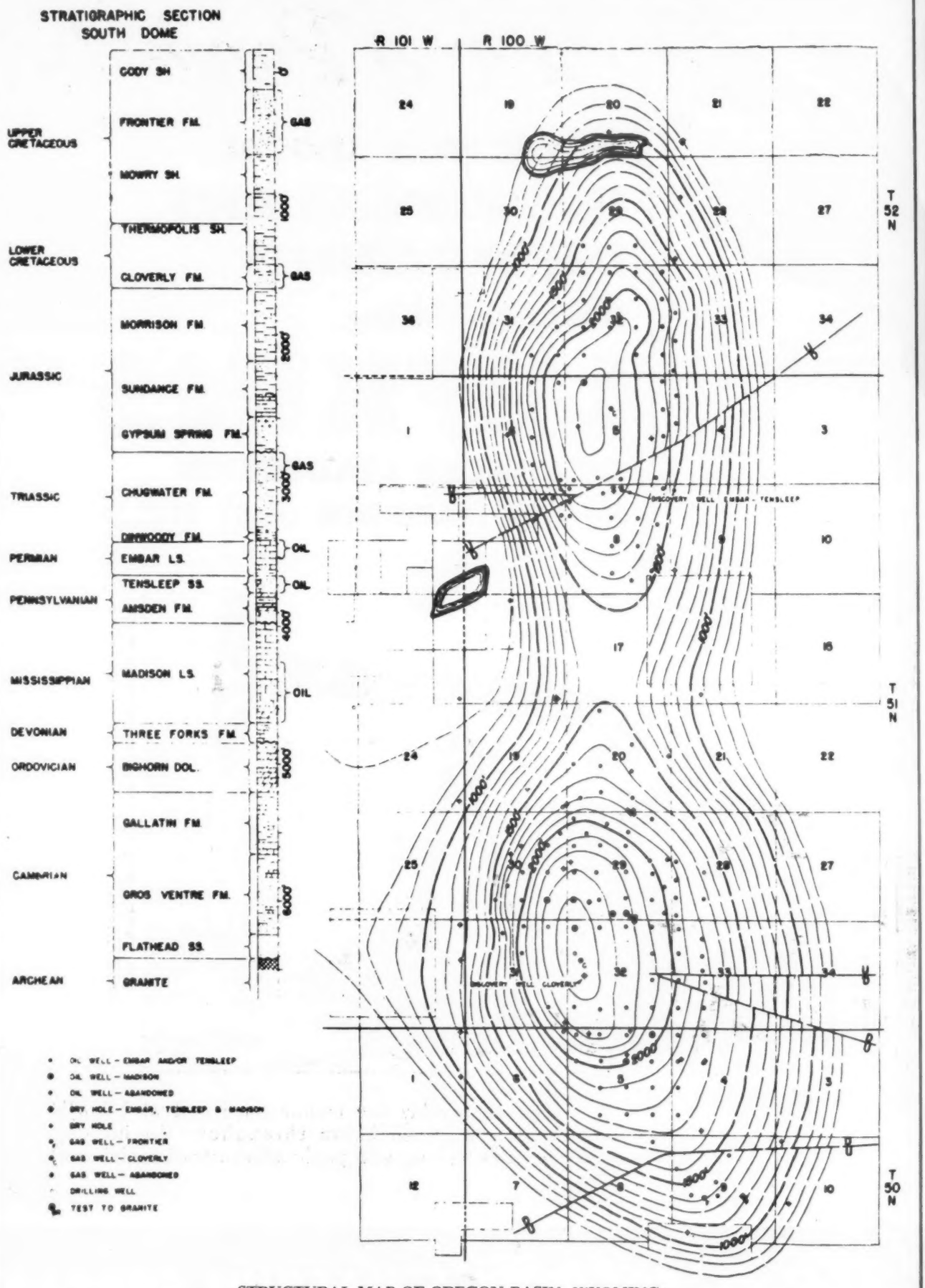

STRUCTURAL MAP OF OREGON BASIN, WYOMING.[1]

[1]Walton, P. T., "Oregon Basin Field," *Field Conference in the Big Horn Basin* (1947), Wyoming Geol. Assn., Plate III, 218

North dome of Oregon Basin field from centrally located topographic elevation.

P 305

Wyoming

Three Zones Produce in Oregon Basin

Big Horn Basin field now operated under unitized control has production from Mississippian, Pennsylvanian, and Permian. Total closure in anticline exceeds 1600 ft

B. W. ALLEN

THE Oregon Basin field is situated in Townships 50, 51, and 52 North, and the west half of Range 100 West, Park County, Wyoming. This field occupies a large topographic depression on the crest of a north-trending anticline lying on the west side of the Big Horn Basin. The Oregon Basin field is in reality two oil fields that occupy two separate and distinct closed domes commonly referred to as the north and south domes. The three principal producing horizons in the Oregon Basin field are the Permian Embar limestone, the Pennsylvanian Tensleep sandstone, and the Mississippian Madison limestone. Oregon Basin is one of the more important oil fields of the Rocky Mountain area.

Structure

Surface. The geomorphic forms of the Mesa Verde outcrops at Oregon Basin illustrate the shape and size of the surface anticline. Outcrops of Frontier sandstone located in the topographic depression occupied by the Cody shale further identify the structural "high." Displacements of the Mesa Verde rim rock and of the Frontier outcrops on the crest of the north dome show the location of the surface trace of most of the faults which are known to cut the Embar-Tensleep zone. The faults all appear to be high-angle tensional and shear fractures and are believed to be of the same age as the folding which produced the Oregon Basin anticline. Lateral relief of the compressive stresses responsible for the anticlinal uplift has been advanced as the cause of faulting.

Subsurface. Adequate well data are available to delineate an accurate structure map on top of the Embar limestone and indicate an asymmetrical fold. The steeper side is on the west toward the mountains, which is characteristic of folding in the Big Horn Basin. The Oregon Basin anticline, which includes the north and south domes has in excess of 1600 ft of closure. The independent closure of the north dome is 700 ft and of the south dome is 900 ft. Anticlinal structure, therefore, is responsible for the oil and gas accumulation. The faulting seems to have been of little significance except in the extreme south end of the south dome in the accumulation of oil and gas.

Stratigraphy

Stratigraphy of the Oregon Basin field will be described to include those formations from the rim rock to the granite.

Upper Cretaceous.

Mesa Verde. The Mesa Verde consists principally of 1200 ft of buff and white standstone interbedded with gray and brown mudstone. This formation forms a large and impressive rim rock which encircles the field.

Cody Shale. The topographic "low" is formed in the easily eroded marine shale whose thickness attains from

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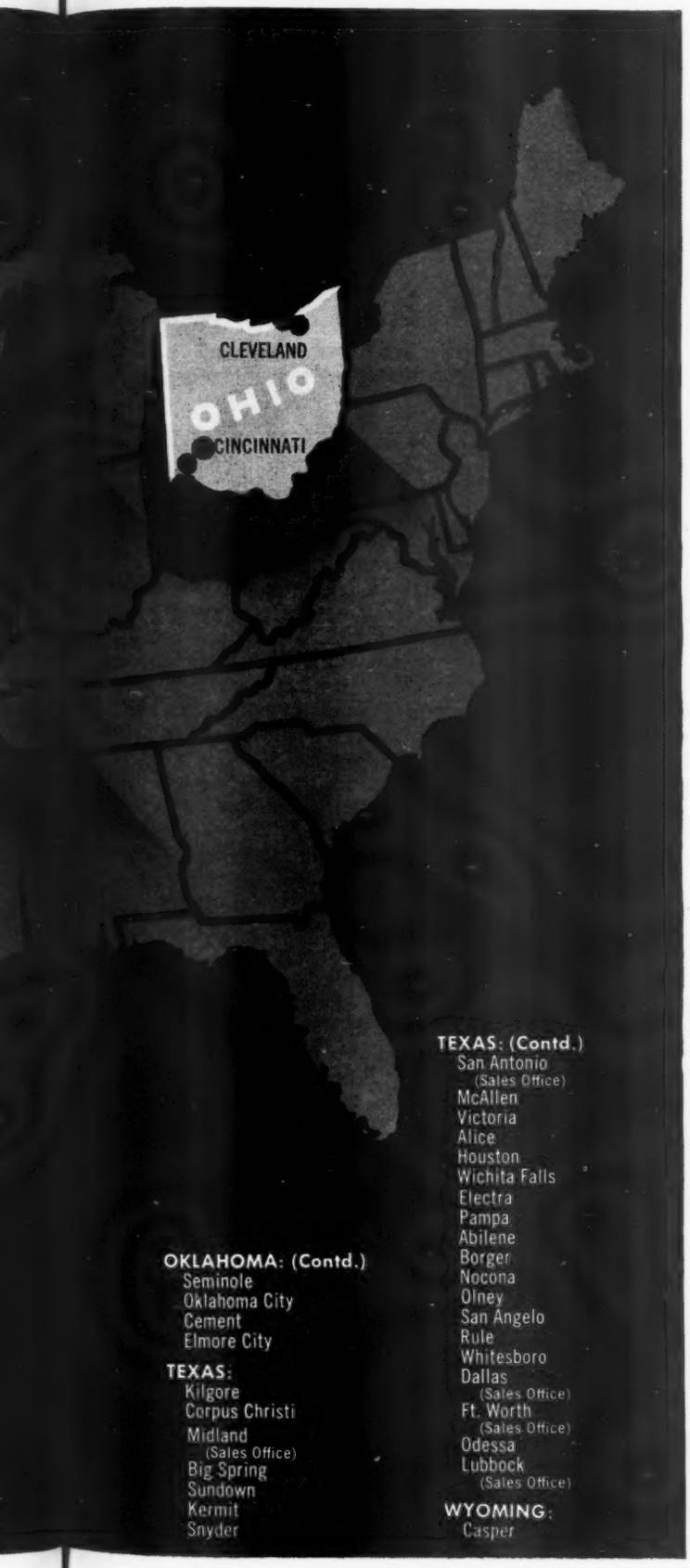

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Oklahoma City
Cement
Elmore City

TEXAS:
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Sundown
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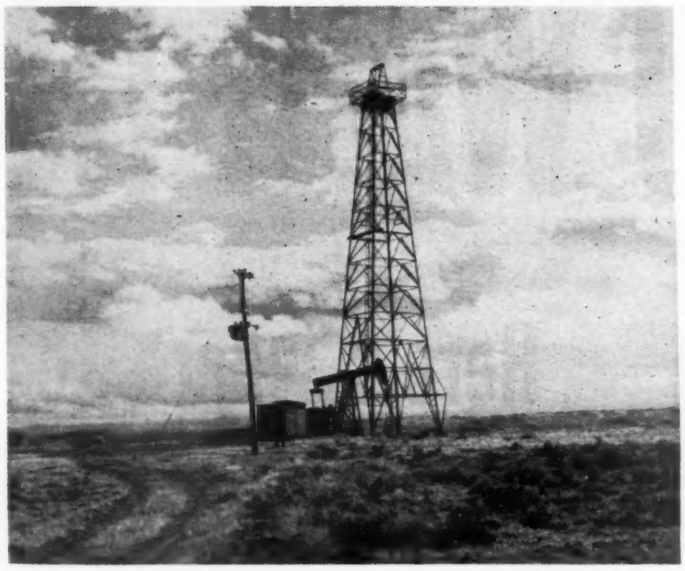
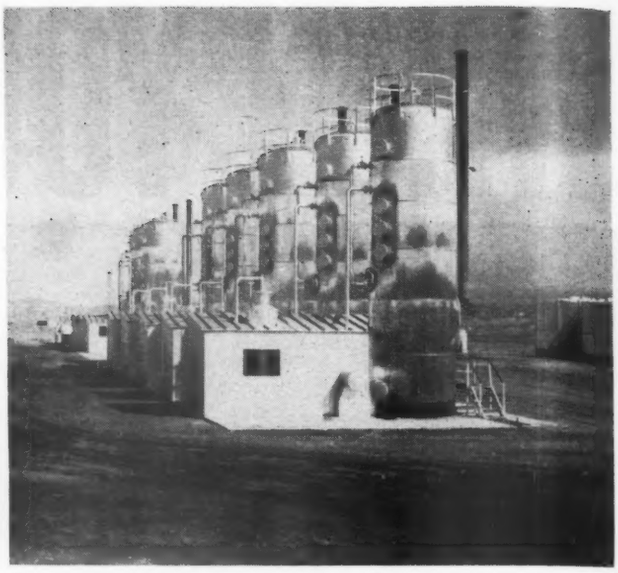


Topographically highest producer in Oregon Basin field.



Separator and treater battery typical of those constructed for unit operation of field.

2150 to 3200 ft in near-by sections.

Frontier Formation. The upper sandstone member of this formation is exposed on the crests of both the north and south domes. Gas is produced from the Frontier in the south end of the south dome. The Frontier consists of an interbedded sequence of 490 ft to 600 ft in thickness of lenticular, gray, massive sandstone, and gray sandy shale containing bentonite beds.

Mowry Shales. The Mowry shales consist of black and gray, platy, siliceous shale containing fish scales and bentonite. The thickness varies from 310 to 360 ft.

Thermopolis Shale. This formation is predominantly black fissile shale and averages 430 ft in thickness. A persistent sandstone member 150 to 170 ft above its base is called Muddy Sand.

Lower Cretaceous.

Cloverly Formation. The Cloverly consists of an 180-ft sequence of light-buff siltstone, gray shale, and gray, clean quartzitic sandstone in descending order. The initial gas discovery at Oregon Basin was made in the basal sandstone of the Cloverly that has been named the Lakota sandstone.

Jurassic.

Morrison Formation. The Morrison is represented by 480 to 515 ft of interbedded green, gray, lavender, pink, and maroon mudstone and shale containing thin lenses of sandstone.

Sundance Formation. The Sundance is composed of an upper sequence of glauconitic sandstone, a middle member of green shale, and a lower member of pink, lavender, and maroon shale containing thin beds of oolitic limestone and white anhydrite. The thickness averages 410 ft.

Gypsum Springs Formation. Gypsum Springs is composed of approximately 80 ft of massive white anhydrite overlying a sequence of maroon, lavender, and green mudstone. The formation has an average thickness of about 240 ft.

Triassic.

Chugwater Formation. This formation is composed of pink and salmon-colored, fine-grained sandstone and siltstone that averages 625 ft in thickness on the south dome. Gas produced from the Chugwater sands has been used in the field in both the north and south domes.

Dinwoody Formation. The Dinwoody consists essentially of pyritic green shale, white anhydrite, and intertongues of maroon shale. The formation averages 30 to 45 ft in thickness.

Permian.

Embar Limestone. Immediately below the Dinwoody lies an interbedded sequence of gray, finely crystalline, vuggy limestone and light-bluish-gray dolomite which is called Embar limestone throughout the Big Horn Basin. The Embar is of marine origin, and is a major oil producing formation in Oregon Basin. Commonly it consists of well saturated, coarsely crystalline, porous limestone interbedded with hard, dense, barren limestone and dolomite streaks. Considerable vertical fracturing is known to be present. The Embar varies from 125 ft thickness in the north dome to 250 ft thickness in the south dome.

Pennsylvanian.

Tensleep Formation. The Tensleep sandstone is another major oil producing formation at Oregon Basin. Its relation to the Embar is apparently transitional. Likewise, the Tensleep sandstone is laterally gradational into a gray, sandy dolomite facies which replace nearly all the sandstone. This transition occurs chiefly on the south dome and may represent all stages between a sandstone with a dolomite cement and a pure dolomite. The Tensleep, which is considered a marine deposit, is composed of well sorted, clear quartz grains. While the top 20 ft show steep torrential type cross bedding, its lower portions are massively bedded. The lower boundary of the Tensleep is usually placed at the first occurrence of red and lavender dolomite or shale, which is considered to be the top of the Amsden formation. The lower boundary of the Tensleep is transitional in the same manner as the upper boundary.

Amsden Formation. This formation consists of a sequence of shale and dolomite with a basal sandy shale grading to sand in the lower 20 ft. The formation averages 210 ft in thickness.

Lower Mississippian.

Madison Limestone. The Madison is essentially a massive limestone averaging 740 ft in thickness. It is a marine deposit of great lateral extent. Porous zones in the lower 500 ft of the Madison are important oil reserves in the Oregon Basin field.

Devonian.

Three Forks Formation. This forma-

The Author

B. W. Allen is division reservoir supervisor in the Casper, Wyoming, division of The Ohio Oil Company. He was graduated from Colorado School of Mines at Golden, Colorado with a production degree in 1948. Upon graduation he began work with Ohio Oil at Oregon Basin. He worked as field engineer in Wyoming and Nebraska until the first part of 1950, when he became reservoir engineer in Casper division. In July 1953 he was named to his present position.

tion is composed of interbedded limestone, green shale, and limy sandstone. It is 205 ft thick in the one well which has entirely penetrated this formation.

Ordovician.

Bighorn Dolomite. The massive, buff, porous, and vuggy Bighorn dolomite is 330 ft thick in the only well to penetrate it.

Cambrian.

Gallatin Formation. This formation is composed of dark green, platy, shale and galuconitic limestone which attained a thickness of 515 ft in the one well which penetrated this formation.

Gros Ventre Formation. This formation consists chiefly of dark, grayish-green, platy, shale and is approximately 485 ft thick in the one well that has penetrated this formation.

Flathead Sandstone. This sandstone lies on the granite. The basal 15 ft contain coarse, angular, fragments of pink feldspar, and quartz. The upper portion is composed of coarse, angular vitreous quartz fragments set in a finer grained quartz sand matrix. The sand has good porosity and permeability. At Oregon Basin, the Flathead has a thickness of about 170 ft in the one well that has completely penetrated the formation.

Characteristics of Producing Horizons

Frontier Formation: Although the Frontier sandstones are exposed on the crests of both the north and south domes, one well in the south end of the south dome produces small amounts of gas. Gas accumulation has been a result of faulting.

Cloverly Formation: Two wells in the north dome produce commercial amounts of gas from the Cloverly. The gas produced from this formation is sold to the gas company which serves the town of Cody. The initial shut-in casing head pressure of the Cloverly gas well was about 680 lb. This reservoir has been producing almost constantly since 1916.

Chugwater Formation: Two wells produce gas from the Chugwater for use in the field. The gas is contained in thin sand stringers which alternate with shale throughout the 625 ft section of the Chugwater formations. The wells have a shut-in casing head pressure of about 1000 psi.

Embar Limestone: Most of the early wells drilled to the Embar were also drilled to the Tensleep and dually completed with both the Embar and Tensleep open. Later wells which were completed only in the Embar have shown a tendency to go to water rather rapidly but to make considerable amounts of oil after water first appears. The Embar wells respond very favorably to acid treatment to increase production. The north dome Embar had a primary gas cap. A small gas cap exists in the south dome, but it is believed to be of secondary origin. On flank locations, the Embar has shown excellent porosity and permeability with initial productivity of some wells reaching as high as 2800 bbl per day.

Tensleep Sandstone: As mentioned briefly, many of the early wells were completed both in the Embar and Tensleep formations. In the recent development history of the field, however, many completions have been made to the Tensleep alone. The Tensleep sand apparently is being flooded uniformly by an edge water encroachment. There are small gas caps in the Tensleep in both the north and south domes.

Madison Limestone: Productivity of wells in the Madison vary considerably. The productivity of this formation seems to be controlled primarily by the amount of fracturing present. There is no gas cap in either dome and the reservoirs are producing by complete water drive. It is expected that the uniformity of water encroachment will be controlled largely by the fracture characteristics of the reservoir and will probably exhibit a production history much the same as the Embar wherein high water-oil ratios were reached after a relatively small per cent of the oil in place has been produced.

Early Development and Production History

The Oregon Basin field was discovered in 1912 when a gas well in the south dome in the NW¼SW¼, Section 32 was completed in the Cloverly formation at 1320 ft for an open flow of 20,000,000 cu ft per day. In 1916, a gas well in the SE¼NW¼, Section 5 on the crest of the north dome was completed in the Cloverly formation for an open flow potential of more than 25,000,000 cu ft per day.

In March, 1927, The Ohio Oil Company drilled a well in the NW¼NE¼, Section 8 on the north dome and discovered oil in the Embar and Tensleep formations. The well produced 800 bbl of 22 API gravity black oil daily.

Gas was discovered in the Chugwater formation in the north dome by a well drilled in the SW¼NE¼, Section 32 in 1928.

In 1930, gas was discovered in the Frontier in the south dome by a well drilled in the northwest corner Lot 2, Section 9.

The Madison was discovered to be productive by a well drilled in 1943 in Section 5, T. 50 N., R. 100 W. in the south dome.

In 1945, Pacific Western Oil Company drilled a well in Section 29, T. 50 N., R. 100 W. in the south dome to granite and found no commercial oil production below the Madison.

Gas from the Cloverly formation is produced and sold to the Cody Gas Company for utility purposes in the town of Cody.

Gas from the Chugwater has been produced and used in the field.

After oil was discovered in the Embar and Tensleep formations, development of those formations proceeded rather slowly. Market demand for the low gravity black crude oil was small until World War II. During the war years, demand for this type oil increased, and, as a consequence, development was accelerated until the time of unitization in March, 1948.

The Madison reservoir in both domes has been steadily developed since its discovery in 1943.

Unitization

During the period of heavy production during World War II and immediately thereafter, the Embar-Tensleep reservoir in both the north and south domes suffered an appreciable decline in bottom hole pressure. Several of the upstructure wells began to produce high gas-oil ratios. Under competitive operations, it was not possible to conserve reservoir energy so that the best ultimate recovery from the Embar-Tensleep might be realized. As a consequence, the major operators in the Oregon Basin field, namely, The Ohio Oil Company, The Texas Company, Husky Oil Company, and Trigood Oil Company, undertook negotiations to unitize operations in the Oregon Basin field. Unitization was achieved March 1, 1948, at which time The Ohio Oil Company took over operations as Unit operator.

All formations below the top of the

Utah Gas Well Complete

Completion of Three States Natural Gas Company's No. 1 C. K. Steiner "A" in Central Utah, Emery County, as a two and one-third mile extension of the Clear Creek gas field has been announced by Three States president, John A. McGuire.

The new well which added a gross reserve of 200 billion cu ft to the field, drilled in for an estimated 20 to 30,000,000 cu ft of gas per day.

Base of the Ferron sand series was at 4825 ft and total depth was 4900 ft in shale.

Top of the Ferron gas sand was found at 4341 ft, structurally 642 ft higher than the company's No. 1 Marry D. Kearns Dakota sand gas producer nine miles to the South and 745 ft lower than its Helen E. Walton "A" No. 3, two and a third miles to the northwest, completed for 112,000,000 cu ft of gas per day, absolute open flow.

XUM

Chugwater to the granite were unitized within the Unit Area as defined in the agreement. Four participating areas were established and are:

(1) North Embar-Tensleep Participating Area,
(2) South Embar-Tensleep Participating Area,
(3) North Madison Participating Area,
(4) South Madison Participating Area.

Present Operations

After unitizing the Oregon Basin field, 48 lease batteries throughout the field were consolidated into a total of 10 central batteries. Appreciable savings in operating costs have been realized because of consolidation. Besides the obvious savings in pumping labor, tank battery consolidation has caused considerable savings in expenditures for emulsion treating chemicals. Oregon Basin crude forms a very stable emulsion which causes a difficult treating problem. Before consolidated tank batteries were built, chemicals were injected at each wellhead where an emulsion was being produced. Now chemical is injected into the header at the consolidated battery so that one injection point serves all the wells connected to the battery. As a consequence, chemical consumption has been cut by about 50 per cent.

Orderly development of all the participating areas has proceeded to keep pace with market demand. Except for gas cap areas in the north and south domes, the Embar-Tensleep has been developed on a density of one well per 40 acres. The Madison has been and is being developed on a density of one well per 80 acres.

After unitization went into effect, all high gas-oil ratio wells were shut-in to conserve reservoir energy. Withdrawals were controlled so as to achieve as nearly a uniform pressure distribution as possible throughout the Embar-Tensleep reservoir. The pressure decline in the Embar-Tensleep has been arrested, and pressures at present are nearly the same as in 1948. For conservation purposes, five wells are now shut-in in the south dome Embar-Tensleep because of high gas-oil ratios. In the north dome Embar-Tensleep, three wells are shut-in for high gas-oil ratios and three wells are shut-in for high water-oil ratios.

At present, the field produces at an approximate total of 15,000 bbl a day from all formations from a total of 185 active wells. A total of approximately 60 million barrels of oil have been produced from all formations to date.

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Walton, P. T., "Orgeon Basin Field," *Field Conference in the Big Horn Basin*, Wyoming Geol. Assn., 1947, 210.

* * *

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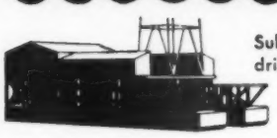
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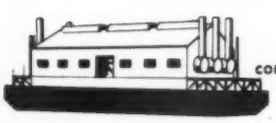
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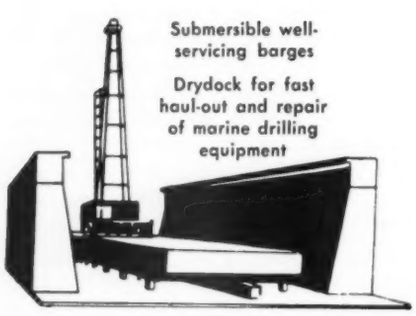
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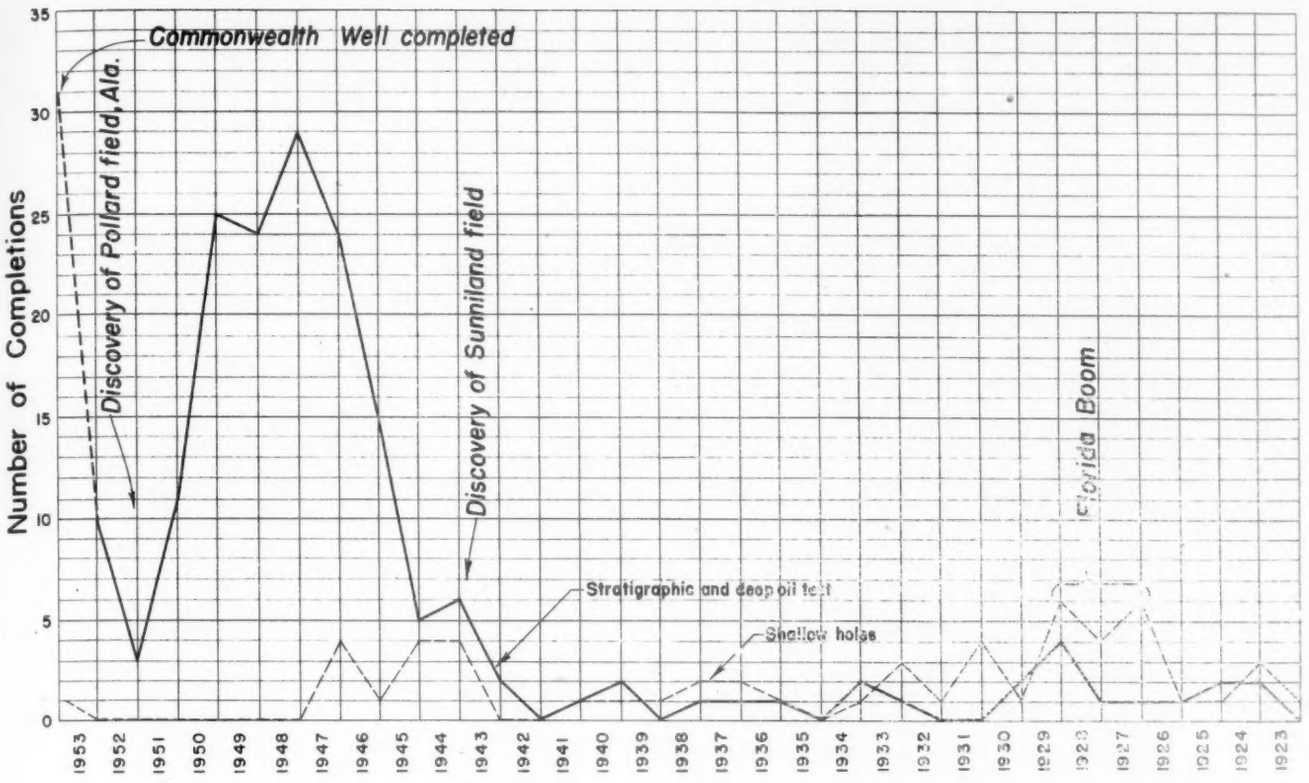

FIG. 1. Completions in Florida, 1923-1953.

FLORIDA — U.S. OIL FRONTIER

State has boom year in 1953 with completion of second discovery well and 31 stratigraphic tests

H. GUNTER and R. O. VERNON

THE search for additional oil reserves in the United States, that sometimes seems to reach a frenzied activity, has once again included Florida as a possibility. Discovery of oil in late 1952 at Pollard, Alabama, just across the state line, caused a determined leasing play that included most of the Panhandle of Florida and reawakened the lagging interest in the rest of the state, particularly in the southern Peninsula. Interest in the southern portion of the state was stimulated by the development of a new refraction technique, useful in thick carbonate and evaporite rock sections.

Exploration in the state has been more active in 1953 than during any previous year, 31 wells having been drilled and completed as dry holes up to November 1, 1953. In addition, three wells are now drilling, one is being tested and will probably make a small well, roads are being built into one well site and two applications to drill have been approved. In all it is anticipated that about 40 completions will be made in Florida in 1953, and with the completion of the state's second discovery well, The Commonwealth No. 1 Wiseheart-Board of Education, last year was the most active and successful year of oil exploration in Florida.

History of Development

The search for oil began in Florida, as nearly as dependable records show, about 1900, at Pensacola, Escambia County. This well was drilled by the Escambia Oil Company at the foot of Palafox Street to a depth of 1320 ft. Since the completion of this well, 281 locations labelled as oil or gas tests have been completed in the state. Of these, many were shallow or were junked and abandoned, and consequently cannot be classified as stratigraphically significant in the interpretation of oil and gas structures and geology. In fact, the state has several hundred water wells that are one to two thousand feet deep and much deeper than many of the wells designated as oil tests.

If only stratigraphic tests and bona fide oil exploratory wells (those drilled with adequate technical supervision or benefit of "clergy") are counted, the state has been penetrated by only 210 deep wells, thus leaving 71 wells drilled for promotion, too shallow to be informative or junked and abandoned. If all of these 210 wells were placed in one of Florida's larger counties, the information obtained would hardly eliminate the county as an oil prospect, considering that each well definitely eliminates only the 40 acres upon which it was drilled.

The drilling activity throughout the 30-year period, 1923-53, has been plotted as Fig. 1. The principal drilling activity was scattered over the last 10 years. Accelerated activity during 1945-49, followed the discovery of the

EXCLUSIVE

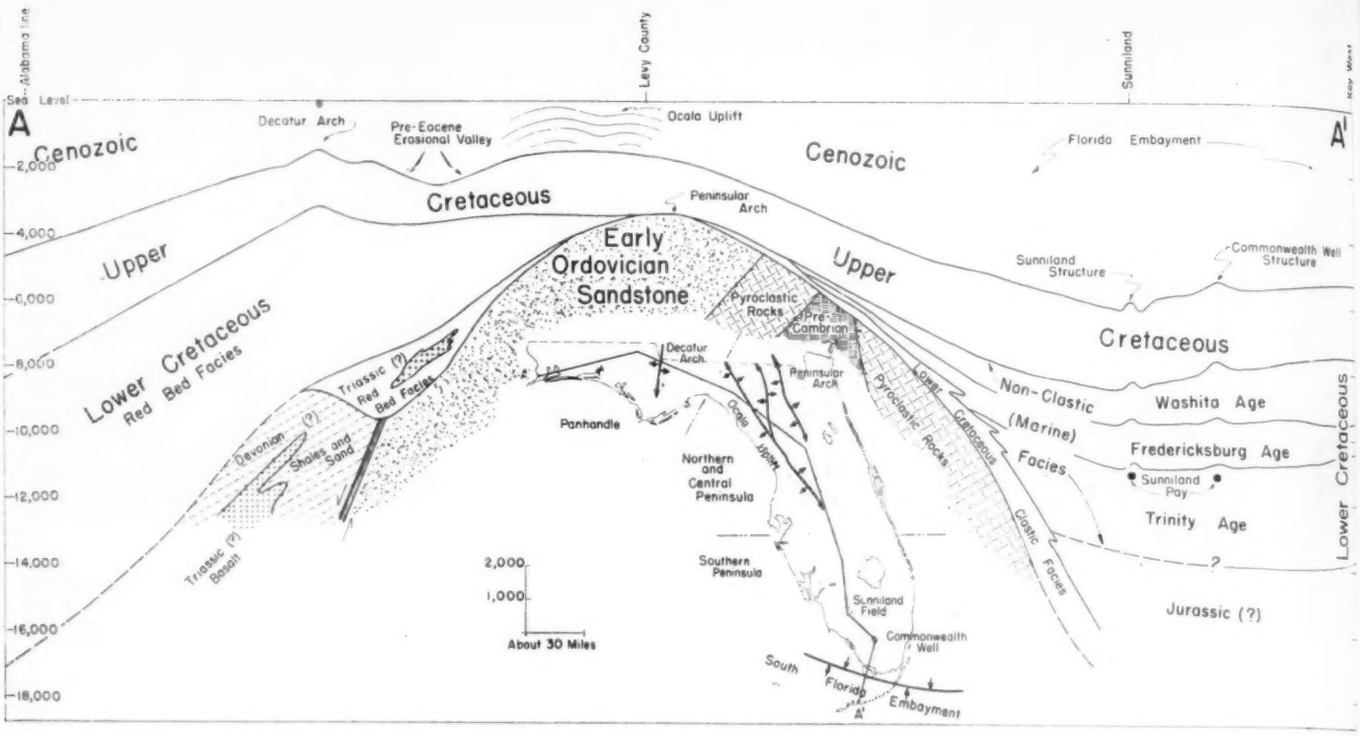

FIG. 2. Foreshortened and diagrammatic cross-section through Florida (with location of structures).

Sunniland field, Collier County, September 26, 1943. A recession in 1951 followed the failure of most tests and the disheartening lack of oil shows in the northern Peninsula and Panhandle; but a sprint of activity in 1953 followed the discovery of oil in the Pollard field, Escambia County, Alabama, in January, 1952, and the demonstrated usefulness of refraction seismology in southern Florida. By November 1, 1953, 31 stratigraphic completions had been made whereas there were 10 in 1952, 3 in 1951, 11 in 1950, 25 in 1949, 24 in 1948, and 29 in 1947, the previous year of greatest activity.

During the interval following the discovery of oil in Florida, 177 deep stratigraphic wells have been completed in the state, whereas six wells were completed in 1943, the discovery year; and 27 prior to 1943. Of these 210 deep stratigraphic wells, 83 were drilled in the Panhandle, 69 in the northern and central Peninsula, and 58 in the southern Peninsula. Most of this differential in the number of wells drilled has been caused by the relative costs of the wells drilled in each section, the northern Peninsula and Panhandle costs per well, as an average, ranging between $18,000 and $150,000, whereas costs in the central and southern Peninsula range from $150,000 to more than $1,000,000 per well.

Sample Library

Through the nearly 50 continuous years that the Florida Geological Survey has operated, persistent efforts have been made to procure samples of rock cuttings and cores taken from wells drilled as sources of water, as drainage controls, and as oil and gas tests. It can be recorded with considerable satisfaction that most of the water well drillers, oil companies, and operators have been most cooperative and willing to collect these samples and submit the necessary descriptive data on each well that they have drilled. These data cover almost every section of Florida and the Survey now has a library that included on November 1, 1953, 3055 wells of which 202 are deep oil tests, and about 200 are stratigraphic core tests. These data comprise a source of information on the geology, minerals and structures of the state, which is of inestimable value to the oil geologist. The Survey makes this library available to all interested students of Florida geology.

Oil Regulations

The state of Florida is among those states that are blessed by a comprehensive and equitable law that promotes the development of oil and gas, assures its conservation, and protects the state's water resources. This law was passed by the Legislature in 1945 and was patterned from a regulatory brochure prepared under the supervision of the Interstate Oil Compact Commission, with such changes as were deemed advisable after public hearings were conducted by the Attorney General and a committee from the Florida Bar Association.

To date, the law and the rules and regulations, prepared from the law, have proved to be adequate and fair. This conservation law is regulated by the State Board of Conservation composed of the Governor and the State Cabinet, and administered by the State Geological Survey. Copies of the law, the rules and regulations and the 12

The Authors

H. Gunter R. O. Vernon

Herman Gunter is director of the Florida Geological Survey. He attended N. C. Agricultural and Mechanical College and was graduated from the University of Florida in 1907. That year the Florida Geological Survey, year of its establishment, appointed him as geological aide and promoted him regularly until in 1933, when the Geological Survey became a division of the Department of Conservation, he was made a director. Author of numerous reports on the geology and mineral resources of Florida, Gunter was given the honorary degree of Doctor of Science from Florida University in 1944.

Dr. Robert O. Vernon, assistant director, Florida Geological Survey, received degrees from Birmingham Southern College, Iowa, and Louisiana. He served as assistant in geology at Iowa from 1935 to 1938, when he became a research geologist for the Geological Survey—1938-1940. For the next three years he served as assistant geologist, at which time he went into the Navy for three years. He became associate state geologist in 1946, accepting his present position in 1953. He is author of many articles on Florida.

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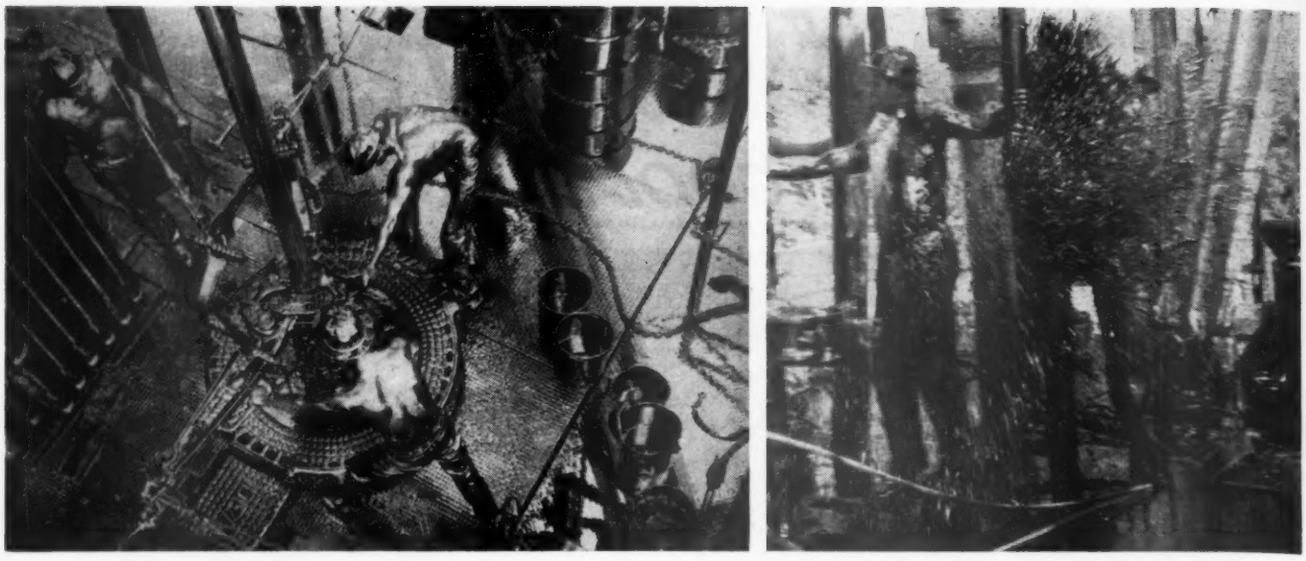

— *Photo by J. R. Galbraith, chief geologist, Commonwealth Oil Company.*

FIG. 3. Two photos of drillstem test No. 1, October 6, 1953, of Commonwealth No. 1 Wiseheart-State Board of Education located in Section 16, Township 54 South, Range 35 West, Dade County, Florida, 40 miles West of Miami.

forms required by the Board can be obtained from the Director of the Florida Geological Survey, Box 631, Tallahassee, Florida.

Geology

Florida comprises 58,666 square miles, all of which is underlain by Coastal Plain sediments. The rocks that compose Florida are a portion of the Floridian Plateau, which has apparently always been a part of a continental mass since the oldest sediments, Early Ordovician, penetrated by deep oil test wells are shallow-water marine deposits of continental shelf deposition. The Mesozoic and Cenozoic sedimentary section of northern and central peninsular Florida consists essentially of fragmental and pasty marine limestones, sandstones and clays reaching a known cumulative thickness in excess of 18,000 ft. The rocks of the Panhandle are chiefly clastics, sands and clays, with minor beds of chalk and limestone and may exceed an estimated cumulative thickness of 20,000 ft. These sediments extend to depths ranging from about 2800 ft in the northern Peninsula to more than 15,000 ft in the southern Peninsula and along the western boundary of the Panhandle, see Fig. 2.

Sedimentary rocks range in age from Early Ordovician through Recent, the section being composed chiefly of Cenozoic and Mesozoic sediments. Three wells drilled in Lake, Osceola and Volusia counties in peninsular Florida penetrated crystalline rocks that Applin (1951) believed to be pre-Cambrian in age. Surrounding these crystallines, in the central and uppermost northern Peninsula, there is a wide band where eleven wells have penetrated lavas and pyroclastic rocks of presumed pre-Cambrian or early Paleozoic Age. Thickness of these is unknown but more than 350 ft of amygdaloidal basalt was penetrated by a well in Highlands County.

Throughout a wide area, centered in the northern and central Peninsula, with one well in Jackson and one in Jefferson County, Paleozoic sediments, ranging in age from Early Ordovician to Devonian(?) are encountered. Thirty-seven wells have penetrated Paleozoic sediments that are chiefly dark-gray or black shale and quartzitic sandstone, unmetamorphosed and horizontally bedded. These beds are encountered at depths below 2800 ft and a maximum of 2250 ft of quartzitic sandstone has been penetrated by one well, but the total thickness of the beds is unknown.

The Mesozoic rocks of the state range in age from Triassic(?) to Upper Cretaceous. In the Panhandle and northern Peninsula, variegated clastic sediments that are considered to be Triassic or Jurassic in age are associated with sills, dikes and flows of basic igneous rocks. In the southern Peninsula the deeper wells terminate in dolomitic limestones and anhydrite that are tentatively placed in the Jurassic. Beds containing Trinity, Fredericksburg, and Washita fossils, chiefly limestone, dolomites, and anhydrite have been recognized in the southern and central Peninsula, but the Comanche series elsewhere is chiefly variegated clastics that were formed on the slopes of a pre-Mesozoic surface, described by Applin (1951) and with the highest portion of the crest centered at Union County, northern peninsular Florida. This structure was submerged by Mesozoic sediments, the submergence advancing northward and beds of Trinity, Fredericksburg and Washita ages overlapping progressively upon the floor of eroded pre-Mesozoic rocks, the marine facies interfingering with the clastic facies along the margins of the pre-Mesozoic floor. Deposition continued through the Upper Cretaceous.

The Cenozoic deposits range in age from Paleocene to Recent and are composed of limestones, sands and clays with carbonates predominating in the Peninsula and clastics in the Panhandle sections.

In general the sediments of the state from the Mesozoic through the Recent are composed of two depositional facies, an essentially marine carbonate and evaporite facies over much of Peninsula Florida and a more shallow-water clastic facies, a small portion of which is also carbonate, in the Panhandle section. The Coastal Plain Province of western Florida and states westward to Texas have been in general a region of active deltaic sedimentation, whereas the Peninsula, removed from large streams and clastic sedimentation, is dominantly marine. The two facies merge through interfingering phases in the northern Peninsula, Panhandle, and coastal areas of Alabama.

Principle Structures

In the subsurface the predominating structure is the Peninsular arch (Applin (1951), a slightly arched and probably extensively faulted structure developed in Paleozoic and older rocks and having the highest point of its crest centered in northern Florida beneath Union County. Overlapping Cretaceous beds have also been slightly tilted, indicating that the movements creating the arch extended into the Cretaceous. The crest of the arch trends northwest and southeast and the highest point is penetrated at a depth of 2800 ft, see Fig. 2.

Beds of the Mesozoic dip steeply, those of the Cenozoic more gently, off of the Peninsular arch and into the south Florida embayment, see Fig. 2, in which more than 15,000 ft of evaporites and carbonates have been deposited. Small anticlinal structures at Sunniland and at Forty Mile Bend break the general southerly dip and give reversals for oil accumulation.

The Cenozoic beds traced westward from the Peninsular arch rise into the crest of the Ocala uplift, a broad anticlinal arch developed in the Tertiary

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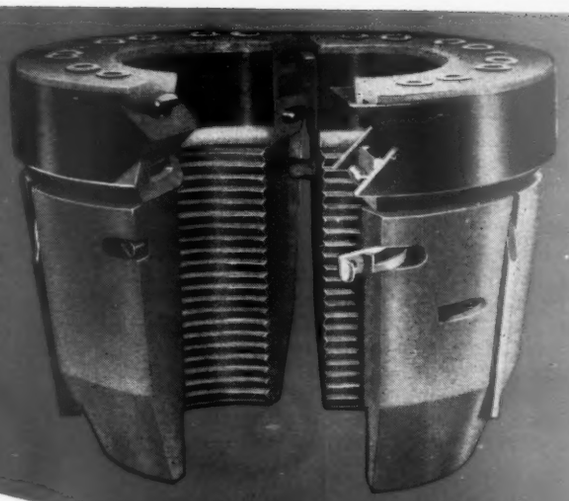

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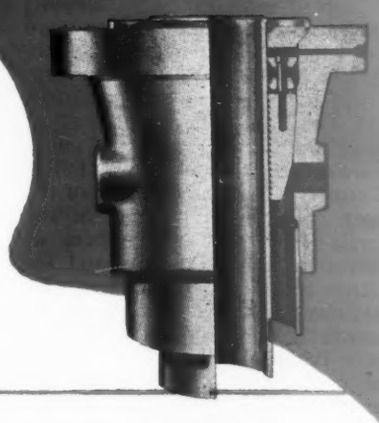

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beds. Crest of the anticline is exposed in Citrus and Levy counties and trends northwest-southwest paralleling the crest of the Peninsular arch, see Fig. 2. Small longitudinal faults have broadened and flattened the crest and small domes give some gentle reversal of dips, see Vernon, 1951.

West of the Apalachicola River, the regional structure is a gentle southwesterly dip broken by a southward plunging fold, the axis of which parallels the Apalachicola and Chattahoochee rivers. This fold, the Decatur arch, is separated from the Ocala uplift and the Peninsular arch by an unnamed, broad but shallow, synclinal basin. The Panhandle section is thought to have been cut by several poorly known faults.

Oil Possibilities

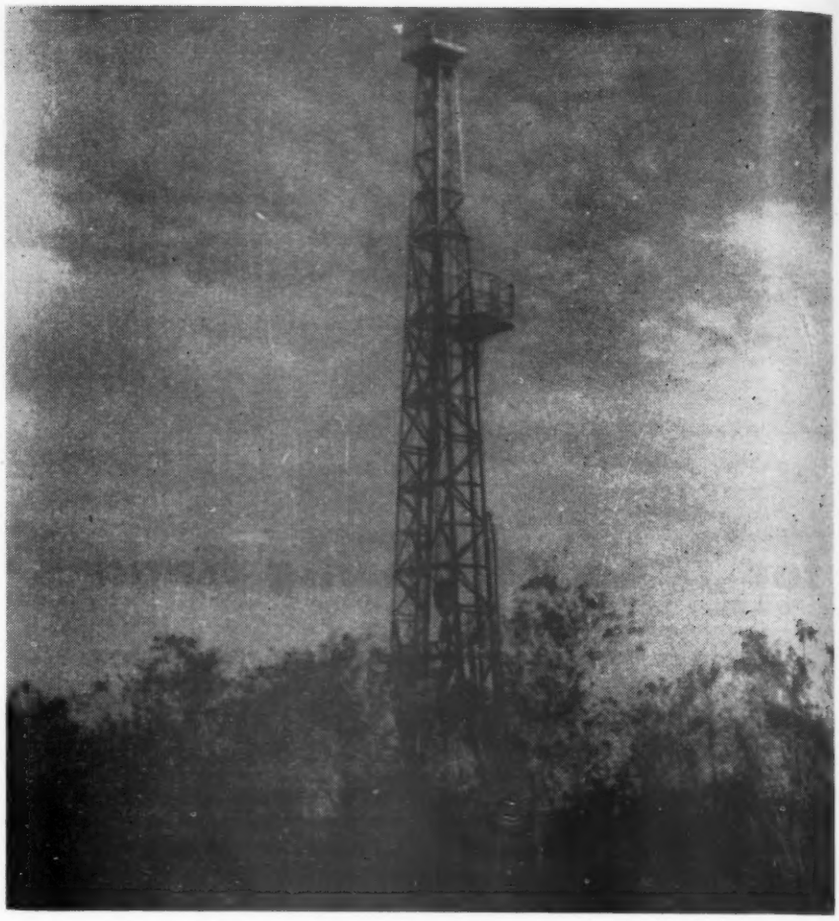
A discussion of oil possibilities can be attempted most easily by dividing the state into three regions based upon units of geology and structure; the Panhandle, the northern and central Peninsula, and the southern Peninsula (see Fig. 2). The Panhandle includes all of western Florida from Escambia County eastward to the east boundary of Jefferson County. All of the counties of the northern and central portions of the Peninsula southward to the base of Hillsborough, Polk, Osceola, and Indian River counties make up the northern and central Peninsula. The remaining, southern, portion of Florida is the southern Peninsula.

The carbonates of the Paleocene, Upper and Lower Cretaceous, are the best prospects for future oil production in the southern Peninsula. A tremendously thickened basin of marine sediments forming the South Florida embayment provides both source beds and stratigraphic traps. Anticlinal folds and domes and possibly some faulting are the most prevalent type of structures. Much of the porosity of the sediments is formed as biostrome and bioherm reefs, with porosity pinchouts in the inner reef areas and where pores have been filled by secondary anhydrite. This area contains Florida's only oil field, the Sunniland field, Collier County, which produces about 1600 bbl of 21-24 deg gravity oil daily. The Commonwealth Oil Company has completed the No. 1 Wiseheart-State Board of Education well in Dade County and preliminary tests (Fig. 3) indicate that the well may be developed as a small producer. This is the second discovery well in Florida and is the most significant development since the discovery of the Sunniland field. Almost every well drilled in this section has had fair shows of oil and with the development of new techniques of refraction seismology the entire area is viewed with considerable hope for further development.

In the northern Peninsula the Cretaceous clastic facies of the Panhandle and the marine carbonate facies of the Upper Cretaceous interfinger and an estimated 3000 ft of Paleozoic sediments is overlain by Upper Cretaceous sediments, Tertiary carbonates and clastics and Cenozoic sand. In the central Peninsula the younger Cretaceous beds overlap the older Cretaceous beds that have overlapped these Paleozoic sediments arched along the Peninsular arch (Applin, 1951). The most promising chance for oil development, the stratigraphic traps on the flanks of this arch, has been extensively prospected with a disappointing lack of oil shows, indications of closures and structures or evidences of petroleum occurrence. Faulting and anticlinal folds developed along the Ocala uplift (Vernon, 1951, p. 54) are probably too shallow for oil occurrence. The entire northern and central Peninsula is saturated with fresh water to depths of 4000 ft in Polk County, 3000 ft in Baker County, 2400 ft in Duval County, and merging to sea level along most of the coasts. Deeply buried domes, faults and stratigraphic traps are the most promising prospects for oil production, although the area is now regarded as the least promising of the three areas. The Paleozoics underlying the area are believed unproductive.

Panhandle geology favors oil exploration. The beds that are known to be productive in Alabama occur at shallow depths, and they are composed of permeable sands. The overlying beds are easily drilled and electric logs and geophysical techniques give reliable results. Primary structures are generally interpreted as faults although some doming and arching has been identified. The structures are generally narrow, limited and hard to find. Continued prospecting should ultimately result in a field in the Panhandle.

In summary it would seem to be highly improbable that only one small field, possibly two, is present in an area as large as the southern Peninsula with so many tests penetrating shows of oil and gas. It is as equally unlikely that Alabama has the only fields producing from the clastic facies. The state has a tremendous volume of sediments containing source beds and adequate permeability and porosity. Difficulties of applying geophysical exploration and of interpretation of the results are beginning to be solved. The costs of drilling in the state are high but demands for additional reserves offset this disadvantage, in part. Considering that the state has been prospected by only 210 deep tests, its future as an oil frontier appears promising. It is anticipated that future drilling will develop new sources of oil leading to the advancement of the state in the ranks of oil producing states.



— Photo by James R. Galbraith, Jr., chief geologist, Commonwealth Oil Company.

FIG. 4. Drilling rig used on Wiseheart No. 1 well, which may prove productive.

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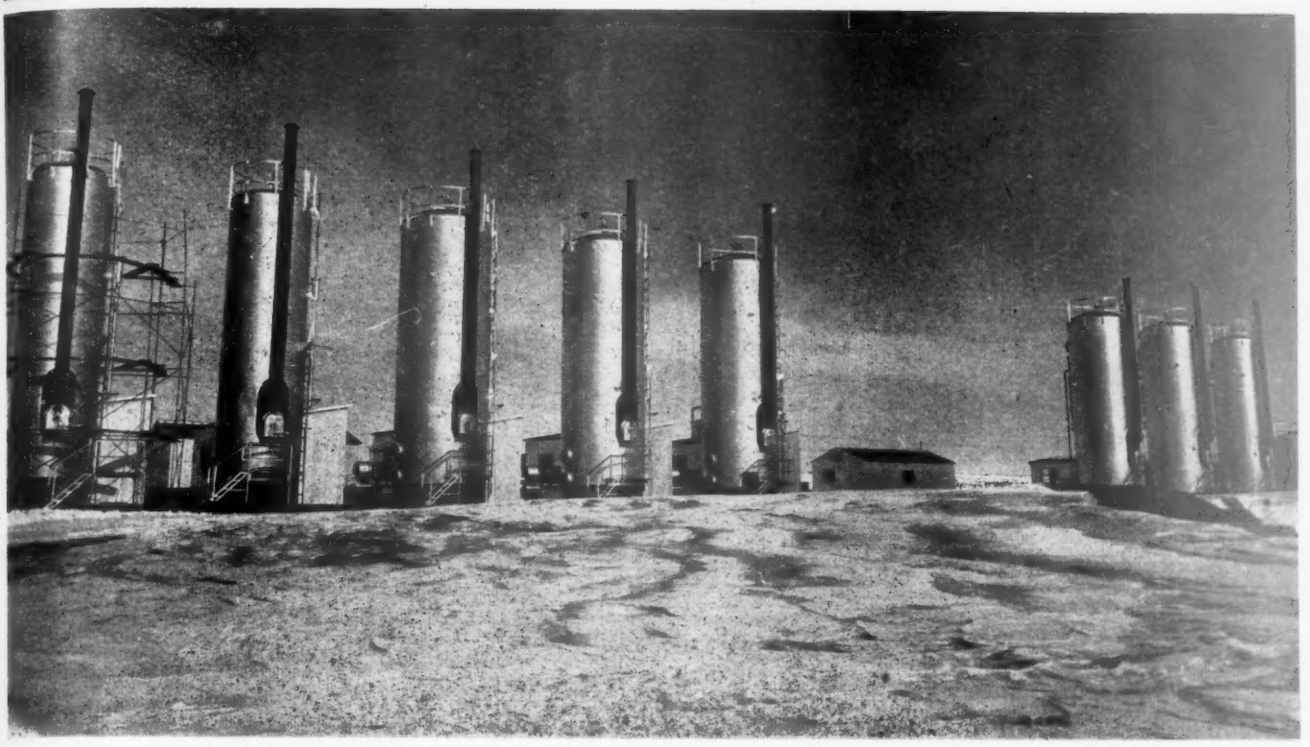

Additional heater-treaters in Oregon Basin field. Note individual separator-heat exchanger houses.
— *Jack Richards Photo.*

Emulsion Reduction in Big Horn Basin

Low crude gravity, not low temperature, is source of most of area's treating problems

M. F. WESTFALL

THE purpose of this paper is to discuss briefly oil treating problems encountered in the Big Horn Basin of Wyoming. Although the Big Horn Basin comprises only a small portion of the oil producing area of the Rocky Mountain region, treating problems encountered there are typical of the entire Rocky Mountain area.

Contrary to popular belief, the principal problem encountered in treating oil in this area is not due to the extreme weather; but, rather to the similarity in specific gravity of the oil and water. Oil gravities in the Big Horn Basin range from 9 deg API to over 40 deg API. By far the largest percentage of the oil produced in the Big Horn Basin has an API gravity of less than 25 deg.

Other general characteristics of Big Horn basin crudes are: Viscosities ranging from about 30 centipoise to over 500 centipoise at reservoir temperature; pour points ranging from about 60 F to well below 0 F.

Most formation water produced in the Big Horn Basin has a specific gravity of very little over one. This similarity in specific gravity between oil and water makes it necessary to employ large treaters with rather large hay sections, thereby making initial investments in treating facilities much greater than is necessary in the Mid-Continent and Texas areas.

Crude characteristics enumerated above result in problems that are closely allied to treating and are, therefore, worth discussing briefly. The large amount of water produced together with these low gravity, high viscosity crudes, result in the formation of heavy emulsions at the pump and in the tubing and flow lines. This results in higher than normal well loads and low pump efficiency. It is necessary to inject treating chemicals down the well to break up these emulsions. Down the hole treating is inefficient and therefore results in higher than normal chemical costs.

As many of the producing fields are small and in rugged terrain, and the demand for the heavy asphaltic crudes have been extremely variable in the past, and since these high viscosity, high pour point crudes are difficult to handle in pipe lines; few of these fields are served by pipe lines. In addition to the difficulty and expense of building and maintaining roads adequate for loaded trucks; the high pour point of these crudes require special facilities to expedite the loading of the trucks. The tanks on many leases are equipped with coils through which steam or hot

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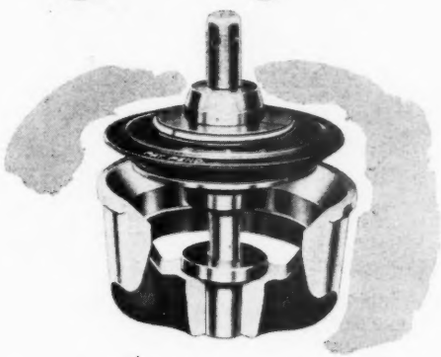

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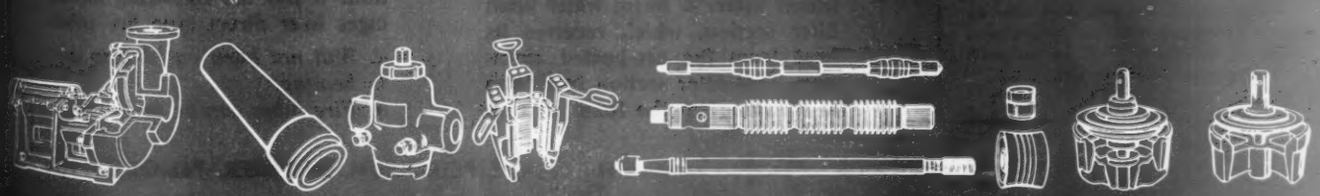

TREATER installation in Oregon Basin field. Ohio Oil Company operates this unitized field. — *Jack Richards Photo.*

water is circulated to keep the oil temperature high enough to facilitate handling. Other leases, where volume of oil produced does not warrant installation of facilities required to circulate steam or hot water through coils, oil temperature is maintained by continuously circulating oil from the tanks to the treater.

Many of the crude oils in the Big Horn Basin have extremely low producing gas oil ratios; such gas that is present is entrained gas. This entrained gas is in the form of gas bubbles in the heavy crude, causing the crudes to foam: And, therefore, do not lend themselves to the conventional methods of oil and gas separation. Further, if these foaming oils were treated in the conventional type treater, most of the entrained gas would be released in the hot water section of the treater. Perculation of this released gas up through the treater would carry water droplets up into the oil section, making it virtually impossible to obtain pipe line oil from the treater. Due to the possibility of water freezing in oil pipe lines, the water cut requirements in the Rocky Mountain Area are more severe than is general in other areas; the usual requirement being that water cut not exceed two-tenths of one per cent.

The above enumerated difficulties require that special consideration be given to design of treaters for use in this area. Special design features of a treater suitable for this area would consist of:

1. **Two stage pre-heating — in which the foaming emulsion goes through a horizontal tube and shell heat exchanger picking up heat from the clean oil leaving the treater, and then passing through a two pass pre-heater immersed in the hot water section of the treater shell. The second pre-heating stage is necessary to heat the foaming product to a high enough temperature to break up the gas bubbles.**
2. **A degasing section — in which the heated emulsion from the pre-heater enters the degasing chamber near the bottom and is released under a warm water filled filter section, which receives its heat from the pre-heated emulsion. This filter section facilitates in breaking up the foam as well as helping to coalesce the water that has broken out of the emulsion by the pre-heater.**
3. **Separation — the gas that is released from the original foaming emulsion leaves the surface of the degasing chamber and enters a standard separating unit wherein the wet gas is scrubbed dry and from which the dry gas leaves through an inside gas line. This inside gas vent line passes through the hot water portion of the treater in order to heat the gas sufficiently to prevent freezing in the back pressure valve.**
4. **A treater shell that will operate at pressures up to 25 PSI.**

Most produced waters in this area have high carbonate and sulfonate content that causes considerable scaling in flow lines and fire tubes, water sections, and hay sections of treaters. This scaling effect of the produced water makes necessary rather frequent cleaning of treaters and in many cases relatively short life for fire tubes. Two rather recent developments have helped to reduce the operating costs due to this scaling effect of the produced water:

A. Chemicals are now available that can be injected into the incoming stream immediately ahead of the treater that serves to retard the formation of scale.

B. Design of a workable horizontal treater — although the horizontal treaters are not new (one of the first models being exhibited at the International Oil Exposition in Tulsa, Oklahoma, in 1948); general field acceptance in this area has not come about until approximately a year ago. The horizontal treater designed for use in the Rocky Mountain area embodies the special design features discussed above. Horizontal treaters have the following additional advantages for use in this area:

1. **Large capacity free water knock out — the free water knock out section is a larger size than in the corresponding sized vertical treater. Waste heat from the emulsion water is used to warm the free water knock out. This increases efficiency of the knock out, therefore, capacity of the treater.**
2. **In addition to the conventional direct type fire tube, the vapor phase fire tube is available in the horizontal treaters. The vapor phase fire tube has the fire tube proper jacketed by a steam section. It has the following advantages over direct type fire tubes:**
   a. Will not burn out due to over heating.
   b. Fire tubes can be immersed in

The Author

M. F. Westfall is assistant to the production superintendent of Husky Oil Company, Cody, Wyoming. A graduate of the University of Colorado, Westfall served during World War II in the Navy. Upon receiving his discharge in 1946, he became a junior engineer for Cities Service Oil Company in West Texas, and the next year went to Bartlesville, Oklahoma, as an engineer in the company's core laboratory. In 1947 he worked in waterflood operations in Kansas, and two years later as district petroleum engineer in Graham, Texas. In January of 1952 he resigned his position to join Husky Oil.

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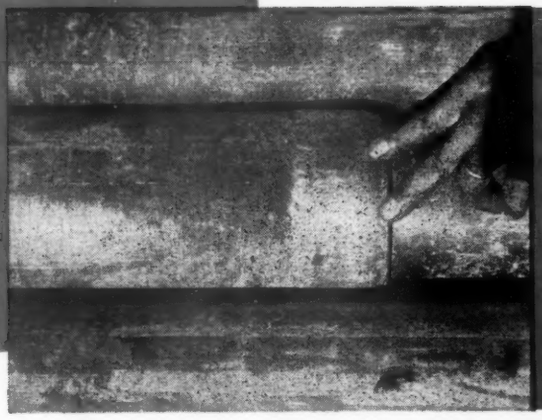

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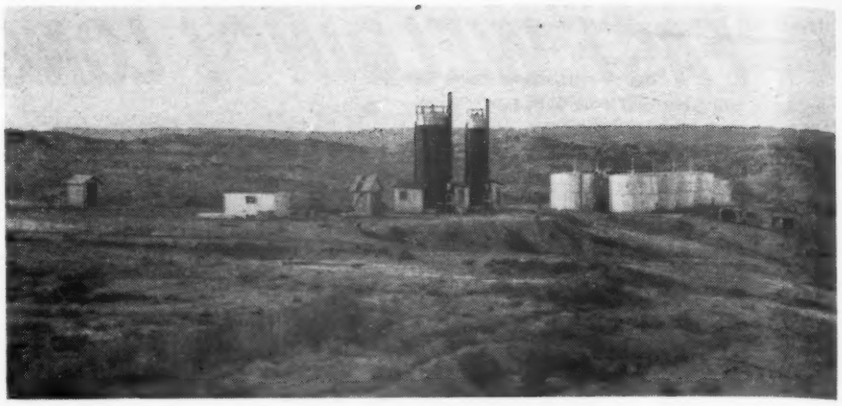
g. Prevents over heating of unit in case of thermostat failure.

h. High or elevated steam pressure is a direct function of dirt or scale on the tube, hence a direct measure of the heating efficiency of the tube.

Our discussion thus far has been concerned with the treating of water-in-oil emulsions; or the so-called "wet oil" that is familiarly found in most producing areas. Far less common, but none the less troublesome, is the oil-in-water emulsion which, in common with some black oil producing areas of California, is encountered in a few Big Horn Basin fields. These emulsions differ from water-in-oil emulsions in that, though they comprise a mixture of oil and water, the oil is in the form of droplets and the water forms the continuous phase or carrying agent of the mixture. Just as the "wet oil" behaves predominantly like oil; these reverse emulsions behave predominantly like water. Oil-in-water emulsions are generally less stable than water-in-oil emulsions, and settling will usually reduce oil content of the water to a very low level, of the order of 0.1 or 1 per cent.



TREATER installation and tank battery at Little Sand Draw, Hot Springs County, Wyoming. — *Courtesy Husky Oil Company.*

Associated with the above problem is the presence of small quantities of fine clay like particles in many of these produced streams. These clay particles usually become oil impregnated. These clay like particles have densities averaging greater than 2.0; whereas, the oil densities are less than one. Therefore, mixtures of oil and clay may have densities greater than or less than that of the water with which they are associated. The oil-soaked clay particles may, therefore, rise to the surface of the water, sink to the bottom, or, more rarely, remain suspended in the water.

In general oil field waters produced in the Rocky Mountain area are not toxic to plants and animals and, are, therefore, disposed of in surface drainage channels. The presence of oil droplets, however, even in the quantities of 1 per cent or less, or the presence of oil soaked clay particles; may tend to cause these otherwise non-toxic waters to be objectionable.

First attempts to solve this problem were to increase the size of settling facilities. This proved unsuccessful, however, because, although oil content can be reduced to a low level readily by settling, removal of the last small quantities of oil by settling is virtually impossible.

The use of chemicals common in municipal water purification systems were tried without success. Electrical dehydration methods were also tried.

When approached from another chemical viewpoint the problem was solved by application of several proprietary chemical reagents of undisclosed but complex composition. These reagents were found to be effective in separating the oil with satisfactory completeness, rapidity, and cost. The oil so recovered has been processed regularly with other wet oil without ill effects in the conventional oil treating procedures, chemical, or electrical. The reagents are entirely different from those employed commercially to resolve water-in-oil emulsions.

As was previously mentioned, the winter weather does not constitute the principle problem encountered in treating oil in this area; however, winter temperatures as low as —40 F do present problems not encountered in most other producing areas. It is necessary, for instance, to bury most flow lines to a depth of four or five feet. The fire box and controls of most treaters are housed, while the remainder of the treater is insulated. Weather conditions together with the character of the produced fluids, make portable, unitized testing equipment such as commonly used in the Mid-Continent area unsuccessful in this area. To successfully test individual wells the year around it is necessary to install a test treater at each lease tank battery.

As shown by the above discussion climatic conditions and fluid characteristics require some modification of equipment and procedures; but, in general, oil treating problems are universal.

* * *

Secondary Oil Recovery Resumed After Droughts

Secondary oil recovery projects, forced to shut down because of the late summer droughts in some areas, have been resumed since recent precipitation has raised the level of parched lakes, streams and rivers, Maxwell Goldhar, president of Sapphire Petroleums, Ltd., Toronto, reported.

Goldhar, whose company's wholly owned subsidiary, Sapphire American Petroleums, Inc., operates secondary recovery projects in Illinois, Indiana, and Oklahoma, said many oil men were hit as hard as farmers by the droughts.

In southern Illinois, where the summer rainfall was down almost 50 per cent, Sapphire's six secondary recovery projects in Clark, Crawford and Lawrence counties were suspended for two months. Sapphire's secondary recovery operations in Rogers County, Oklahoma, were slowed down by the drought but not halted.

"Pressure at the bottom of the oil reservoir only can be built up over a period of time," Golhar explained, "and usually it takes from one to two years of constant water flooding to get a well into top production. Soon after we began our Illinois operations we were producing 1500 bbl a month. Now we are getting about 4500 bbl a month, but if we had not been forced to suspend operations because of the lack of water we would now be producing 15,000 to 20,000 bbl per month.

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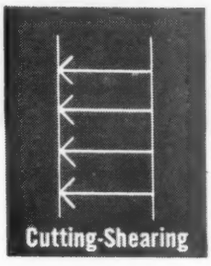

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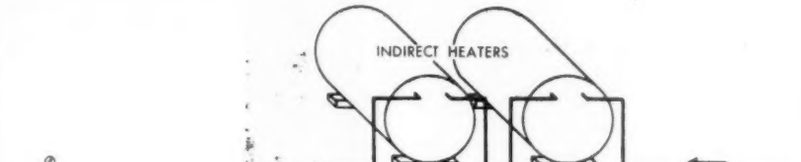

FIG. 1. HOT OIL CIRCULATING SYSTEM.

A STUDY IN SAFETY

Dangerous sour gas in Worland requires detailed planning and strict execution of rules for survival

C. M. HARDEN and J. I. MORRIS

SAFETY in industry, in this particular case, the oil industry has been a practice synonymous with good and efficient operation since the inception of mechanical procedures. Discovery well of the Worland field, Worland Unit No. 1-E, immediately impressed upon the operator that general safety practices were going to be greatly complicated by the presence of toxic hydrogen sulfide gas in the well stream. This presence of toxic gas in the well stream, coupled with high surface pressures and severe hydrate formations, made safety a mandatory and ever present factor in drilling and producing the field. In the attainment of safety program, the safeguarding of life from the hydrogen sulfide gas has been given primary consideration in the selection of equipment and drilling and producing techniques. From the time gas became evident on the drill stem test at Worland Unit 1-E, it was understood that new procedures would have to be developed and ramifications made on old procedures to safely and efficiently produce the field. The means by which these procedures were undertaken and successfully completed, represent the means by which the field was operated in a safety minded manner.

Strangely enough, the first development was not entirely the result of hydrogen sulfide gas, but rather the result of severe hydrate formation. These hydrates indirectly created a distinct hazard as they necessitated additional work around the well, resulting in pressure surges on tubing and valves when the hydrates broke free during producing operations and caused undue stresses to be placed on well equipment. This hydrate condition appeared at Worland Unit 1-E when irregular decline in well production denoted probable mechanical trouble in the well. In running a measuring line it would be found that the tubing was plugged with hydrates. The ice was eventually drilled out; however, it was noted that new hydrates would form nearly as rapidly as the initial ice was drilled out. In order to reduce this hydrate formation, it was found that the most economical and efficient method was through the application of heat. A hot liquid circulating system was installed whereby heat could be applied to the well tubing. Flowing the well effluent through flow line heaters was the means of providing heat to the effluent in surface facilities.

Fig. 1 illustrates diagrammatically the hot liquid circulating system and surface heater installation. In this system, reciprocating or centrifugal pumps driven by electric motors take suction from a 30-bbl galvanized steel surge tank and discharge through indirect heaters rated at 1,500,000 Btu per hour to the well head. The heaters raise the temperature of the incoming liquid upwards to 180 F. Flow in the well is down the annulus between the 2½-in. tubing and the 5-in. casing, to approximately 3500 ft, and up the annulus between the 5-in. casing and 7-in. production string where the liquid returns to the surge tank. Well head

P 934.

EXCLUSIVE

The Authors

C. M. Harden J. I. Morris

C. M. Harden is division production superintendent of the Rocky Mountain producing division, Pure Oil Company. After attending Oklahoma University, Harden spent two years handling various jobs in the production department, Oklahoma, for Magnolia Petroleum Company. The next 11 years he spent with States Oil Corporation and subsidiary companies in Texas, holding numerous titles. He joined Pure in 1934 as assistant superintendent at Van, Texas, receiving his present title in 1937.

J. I. Morris joined Pure Oil as a junior production engineer in 1949. He is a graduate of the University of Colorado obtaining his MS degree after World War II. After a short time with Stanolind Oil and Gas Company, he joined Pure. From 1949 until 1951 he served as acting division production engineer in the Rocky Mountain division, when he was called back into the Navy. He became division production engineer in 1952.

temperature drop between the inlet and outlet of the system varies from 35 F to 75 F. To provide for a minimum heat loss, circulating lines from the heaters and production lines to and from the heaters are either insulated or buried, or both. Water was used as the circulating liquid in the initial system; however, because of the inherent disadvantages of water in below freezing temperatures, which exist for some five months of the year, the water was replaced with oil as the circulating liquid.

While running production tests on Unit 1-E, well pressure entered the circulating system from a tubing break and opened a crack in a hydraulic swedge nipple on the Christmas tree, permitting a large volume of toxic hydrogen sulfide gas to escape. There being no immediate way to stop the leak, inhabitants in the vicinity were evacuated and the well set on fire to prevent any further accumulation of gas, and to safeguard the personnel in the area. Although no surface control could have prevented this type failure, a safety system was devised for placement on the circulating system to prevent well pressure from reaching the surge tank, low pressure pipe fittings. In case of a tubing break or a packer failure, well pressure would be retained on the inlet line of the circulating system by a high pressure check valve; and on the outlet line of the system by a pilot operated excess pressure shut-in valve. These valves would serve to shut off the surface connections on the annulus and prevent escape of the toxic well fluids to the atmosphere. All pipe and fittings to and including the valves, are of design standards sufficient to withstand full well pressure. The circulating pump is equipped with a pressure relief valve which discharges into the suction in the event of a closing of the safety valves.

It was also on the discovery well that the inadequacy of conventional pressure gauges in sour gas type service was observed. Gauges with bourdon tubes of stainless steel and other corrosion resistant metal were tried without success as the tubes would rupture and allow escape of the toxic gas. This problem was corrected by using a gauge which utilized a diaphragm type protector to separate the bourdon tube assembly from well fluids.

With the knowledge gained from Unit 1-E, completion procedures were set up for future wells in the Worland field. During the early development of the field, shut-in well head pressures often approached 3000 psig. In many of the wells the plugging of tubing and flow lines by hydrates was further aggravated by the plugging action of a black substance of asphaltic base combined with miscellaneous foreign materials. The black substance usually appeared immediately after completion and tended to lessen in occurrence with continued production. When either the hydrate or asphaltic type plugs would break free, the flow lines and burn lines would be under a severe strain. Consequently, in order to provide for the utmost safety during clean-up operations, all pipe and connections from the well head to the burn pit were of design specifications of a minimum 6000 psi test. These lines were securely anchored at all possible stress points to prevent movement which might result in breakage and escape of gas to the atmosphere. A sweet gas pilot flare was located at the well-side edge of all burn pits to serve as a source of immediate ignition for any vapors or liquids coming from the well. After initial completion, acid jobs or remedial work, all wells were cleaned in the burn pits in an attempt to free the tubing of all obstructions which might later result in a slugging effect on the tree.

With oil wells being successfully completed, the next problem that faced Worland field operators was the separation and storage of the well fluids. Initially, the well effluent was flowed through the production heaters, two-stage separation, and into stock tanks. Two-stage separation resulted in excessive loss of toxic gas from the stock tanks. To correct this loss, a shop-made separator was installed near the tank battery to operate at a pressure of two ounces. Gassing in the tanks was reduced by venting direct to the flare those vapors breaking out of the oil in the pressure drop from the 50 psig second-stage separation to the two-ounce third-stage separation. A vapor system was designed for the Worland tank batteries to serve three purposes; specifically, (1) prevent escape of the toxic gases to the atmosphere, (2) reduce stock tank vapor losses by maintaining a two-ounce pressure in the tanks, and (3) prevent air from entering the tanks by maintaining a sweet gas blanket. Items (1) and (3) were definite safety measures as the toxic gas is always a hazard; and the exclusion of air from the tanks lessened the possibility of a tank explosion from spontaneous ignition of iron sulfide. Fig. 2 illustrates the production hook-up and vapor system.

In the vapor system, a two-way valve on the vapor outlet connection from each tank was normally open to the main vent line on which a gas regulator maintained a two-ounce back pressure. A sweet gas supply regulator that was set for approximately 1¾ ounces fell below the two-ounce sour gas venting pressure. The second line served as a by-pass around the regulator from the tank to the flare. Flash backs from the flare were prevented by a core-type flame arrestor.

Immediately prior to opening the thief hatch to gauge a tank, pressure in the tanks was reduced by operation of the two-way valve lever which closed the main vent line and opened the toxic gas by-pass line. This procedure isolated the tank and minimized the escape of vapor through the open hatch. As an additional safety measure,

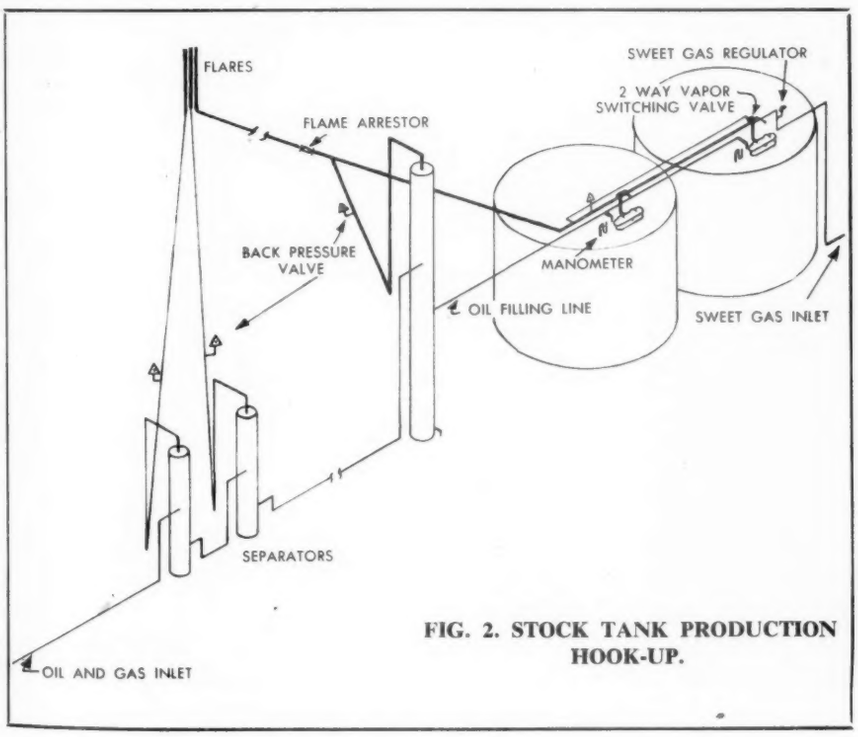

FIG. 2. STOCK TANK PRODUCTION HOOK-UP.

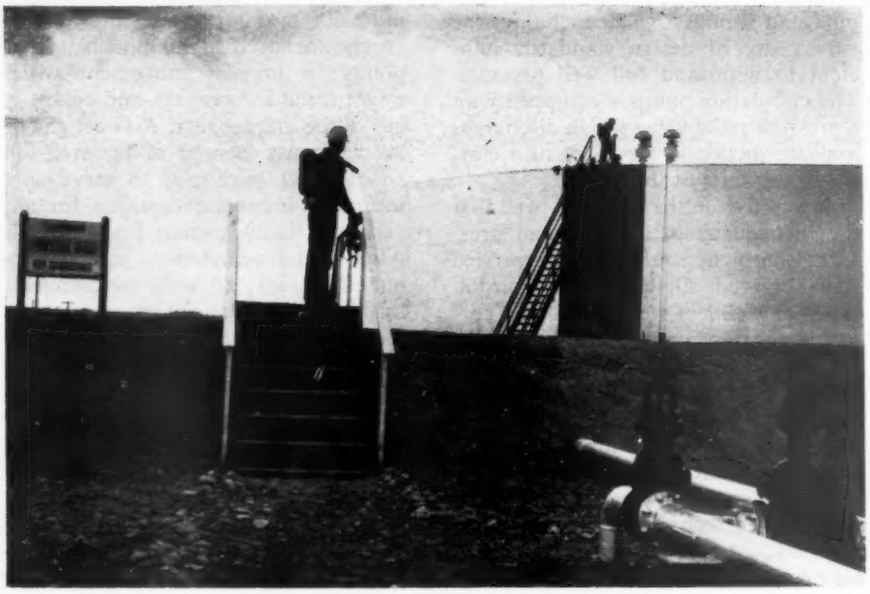

FIG. 3. TANK GAGING PROCEDURES.

the hatch cover could not be lifted until the valve is opened to the by-pass line. Correct operation of the system was checked by a manometer installed near each hatch.

Realizing that mechanical equipment does not always function properly, double stairways were installed on tank walkways to permit exit from either end. Tank batteries were so located as to take advantage of the prevailing wind which would assist in dissipating any loss of gas from tank hatches or minute leaks in tank connections. Field regulations state that any person going onto a tank walkway must wear a gas mask, and that a second person equipped with a gas mask remain at the fire wall. Correct tank gaging procedure is illustrated in Fig. 3. The latter part of the above regulation, in principle, is one of the most important safety practices in the field. The inhalation of a high concentration of hydrogen sulphide gas will usually result in immediate asphyxia. Therefore, time is of the essence in removing the gassed individual from the contaminated area and securing medical attention. Consequently, field personnel approaching possible gas areas always have a second party standing by outside of the probable gas area.

The necessity for the continual use of gas masks is obvious. The standard oil field cannister-type mask did not prove adequate or satisfactory for the Worland needs, as it is ineffective against a maximum hydrogen sulfide content of 2 per cent. Oxygen generating cannister-type masks have been used and are available for an extreme emergency; however, their effective use was limited in that several breaths in uncontaminated air are required to start the oxygen generation; the unit is bulky for the wearer; and once the expensive cannister is opened, it cannot be used intermittently over a prolonged period as the generating chemicals deteriorate in a very short time. To satisfy field needs, the fresh-air type mask was adopted and has proven thoroughly satisfactory for all usage. Air flow to the face piece is through a pressure reducing regulator from a high pressure cylinder that is mounted on a harness carrier, which carries the cylinder on one's back. A small pressure gauge, mounted below the face piece, warns the user when the air supply is approaching depletion. This type mask is shown in Fig. 4.

Two complete fresh-air type gas masks are assigned to each switcher pick-up truck. Each switcher is furnished with a personal face piece which he maintains. Resuscitator units and three major fresh-air cylinder batteries, which are used to refill individ-

FIG. 4. Fresh air type gas masks.

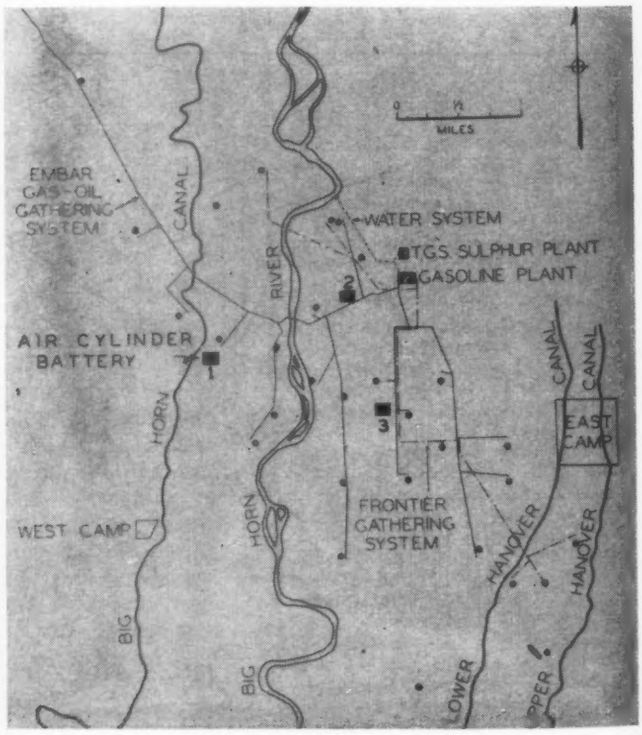

FIG. 5. Wells and facilities in Worland field.

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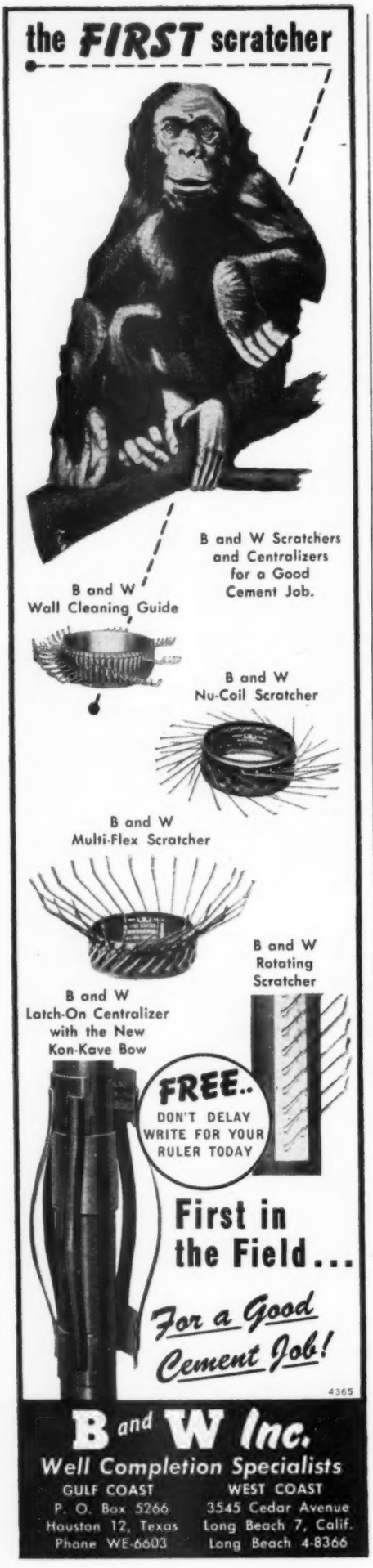
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ual cylinders, are located in the field. These locations are shown as dark numbered squares on the general map of the field in Fig. 5. Oxygen therapy units, gas masks, face pieces, cleaning solutions and replacement filters are kept at switcher's doghouses for ready and immediate use.

The discussion to now, in general, has been limited to the first period of operation where the field was developed competatively by four operators. The field was unitized in 1950 with The Pure Oil Company as operator. All Embar wells now produce into a common gathering system which moves the well effluent to the gasoline plant. Oil is separated from the gas, the oil stabilized; and the gas sent to the Texas Gulf Sulphur Company sulfur plant where the hydrogen sulfide is extracted. The sweet gas is returned to the gasoline plant to be processed.

The Embar Gas-Oil Gathering System was designed to operate between 320 psig and 375 psig with the entire system being subjected to a hydrostatic test of 850 psig. All of the piping in a system varies from 4 in. to 16 in. in diameter, was so designed as to allow for an internal corrosion allowance of 3/16 of an inch, and still maintain minimum test properties. The terrain through which the line was laid is characterized by "hot spots" in the soil. To protect the system from external corrosion, all pipe was coated and wrapped and provided with cathodic protection. It was felt that these two precautionary measures were of the utmost importance as any failure in the line would result in the escape of large volumes of hydrogen sulfide to the atmosphere. Protection of the system from excessive pressure is provided by pressure relief valves located on each leg of the gathering system. These valves, which are set at 400 psig, discharge to a flare that is equipped with a sweet gas pilot light. As wells in the field float on line pressure, individual wells are protected by pilot operated valves that will close with excessive gathering system pressure. Check valves are installed to prevent counter flow from the system to the well. All piping and connections from the wellhead to and including the pilot operated valve has had a minimum test of a 3000 psig.

A portable well checker unit is used to determine individual well production of liquid and gas. The unit is connected to the flow line by means of movable steel hose downstream from the pilot operated valve. At the completion of each day's testing, the entire testing unit is purged with sweet gas to make certain no leakage of hydrogen sulfide gas will occur while the unit is in storage.

Decline in bottom hole pressure has necessitated placing some Embar wells on artificial lift through the medium of gas lift. The valve selected for this purpose contains a positive check valve to prevent counterflow of the well effluent into the annulus where the toxic gas could enter the sweet gas system and result in failure of controllers on the gas lift system. Protection against such a failure is definitely a safety measure, as any failure of mechanical equipment can effect leakage of the toxic gas.

With the start of the second period of operation, storage facilities for crude oil were consolidated into a tank farm consisting of one 55,000 bbl tank and two 10,000 bbl tanks. After separation of the Embar well effluent at the gasoline plant, the crude oil is stabilized and flowed to the tank farm for storage. The 10,000-bbl tanks, which function as production tanks, are equipped with a vapor exhaust system which carries vapors breaking out in the tank to a flare located outside of the fire wall some 200 ft. The 55,000-bbl tank is equipped with a 10-in. flame arrestor which serves to vent any escaping vapors. Field regulations regarding the use of gas masks and procedures apply to personnel going onto these tanks also.

The gasoline plant observes the general safety rules, which have been discussed for procedures in the presence of hydrogen sulfide gas. Plant operations immediately associated with sour gas include the separation of the high pressure Embar well stream and the stabilization of the crude oil at approximately 75 psig. In both operations, high concentrations of hydrogen sulfide gas are evolved and transmitted to the Texas Gulf Sulphur plant. The normal operations of the gasoline plant demand the practice of safety in all instances; and included at the Worland gasoline plant are the extra precautions to be taken in a possible toxic gas process area. Fresh-air type gas masks, resuscitator units and oxygen therapy units are maintained in the process area. Strips of lead acetate paper are available to check for the presence of hydrogen sulfide in working areas. These strips turn dark when the concentration of hydrogen sulfide exceeds the lower toxic limits.

In the second period of operation, wells have been completed in the Frontier formation; and some Embar wells have been recompleted as Frontier wells. A portion of these recompletions have been dual completions in two Frontier sands. As initial shut-in well head pressures in the Frontier and Embar zones were similar, duplicate Christmas trees were used for both Frontier and Embar completions.

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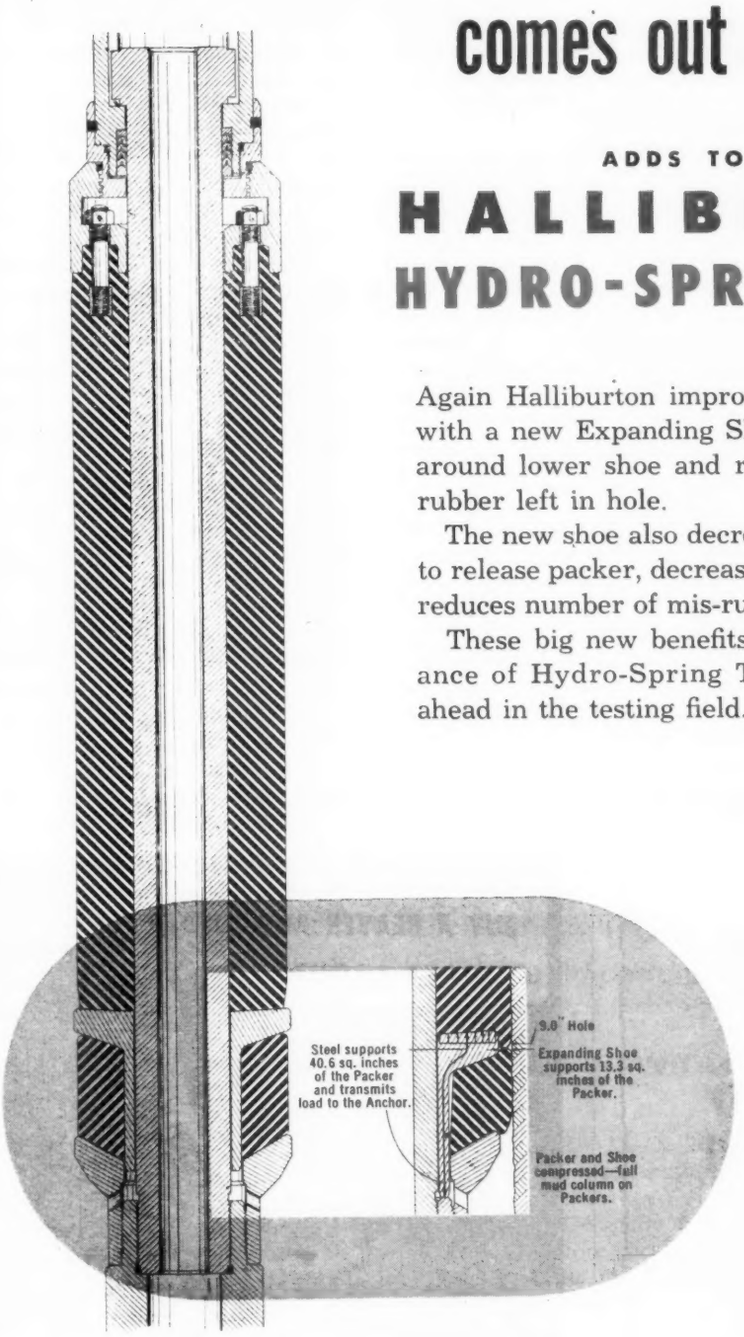
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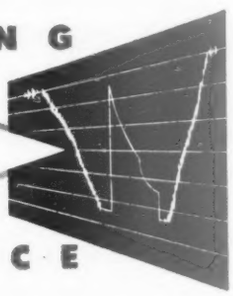

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To assist personnel in rapidly determining the zone on which surface equipment is installed, control valves and other equipment have been painted identifying colors; specifically, Second Frontier, green; Third Frontier, blue; Fourth Frontier, orange; and Embar, yellow. In addition, master gate valve control wheels on all wells are painted red. Through these means of identification, personnel are always aware of the toxic Embar equipment and can adopt the additional precautionary measures necessary.

By far, the most important part of any safety record is the safety education and training of personnel. The best protective equipment in the hands of untrained personnel is inadequate in the interest of safety. The training in the use of protective equipment was of prime importance in the Worland field, as severe poisoning from hydrogen sulfide gas seldom gives an individual a second chance to learn to be careful in its presence.

To prevent just such a loss of life or severe injury because of a lack of proper indoctrination, personnel were given thorough training in the characteristics of hydrogen sulfide, the care and use of gas masks, the importance of having a properly equipped person standing by when necessary for an individual to enter a possible toxic gas area, and lastly, to always treat the gas with the respect it warrants. Of utmost importance was to impress upon all personnel the fallacy of going into a gaseous area without a gas mask, even to effect a rescue. It is beyond the capacity of the average individual to hold one's breath sufficient time to move a second party from a thoroughly contaminated area.

Likewise, it was important to educate personnel as to the actions to take in the event they were hit with a minute concentration of gas. All were instructed, that wherever possible, to work with their backs to a prevailing wind; and if contacted by gas, to run into the wind inasmuch as is possible. Personnel were also instructed in the use of the resuscitator and oxygen therapy units. Thorough knowledge of the use of these appliances could possibly save a co-worker from death if used correctly and in time.

The training and education of Worland field personnel was conducted in safety meetings and under the continuous and complete surveillance of supervisory personnel. Close supervision on well completions, well production tests and pipe and connection work is, undoubtedly, one of the most important contributions to the Worland safety program. Under the guidance of the supervisors, personnel were trained in safety by working with safety.

To the men in the field; the roustabouts, truckers, switchers, plant operators, helpers, loaders and mechanics, should go a lion's share of the credit in maintaining safe working conditions in a field of this type. For the majority of the men, the Worland field was their first experience in oil field work—they were introduced to oil production practices in one of the most hazardous types of oil fields. In view of these circumstances, their safety record, which is in part the result of strict adherence to instructions and field procedures, is indeed creditable.

At the time the Worland field was discovered, concentration of hydrogen sulfide in the produced gas was considerably in excess of any concentrations that had been encountered previously. Through safety education, training and equipment, the employees and employer have achieved an enviable safety record in which no fatalities have resulted from hydrogen sulfide poisoning. It is hoped that the lessons learned, and the methods used in pioneering the development and operation of a field where the gas contains a high concentration of hydrogen sulfide, will prove of aid to other operators in setting up safety programs in comparable fields. * * *

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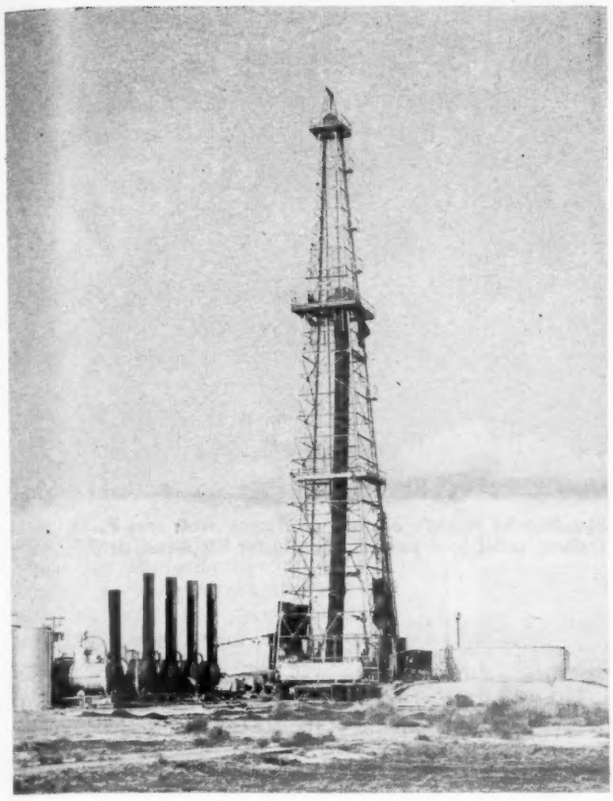
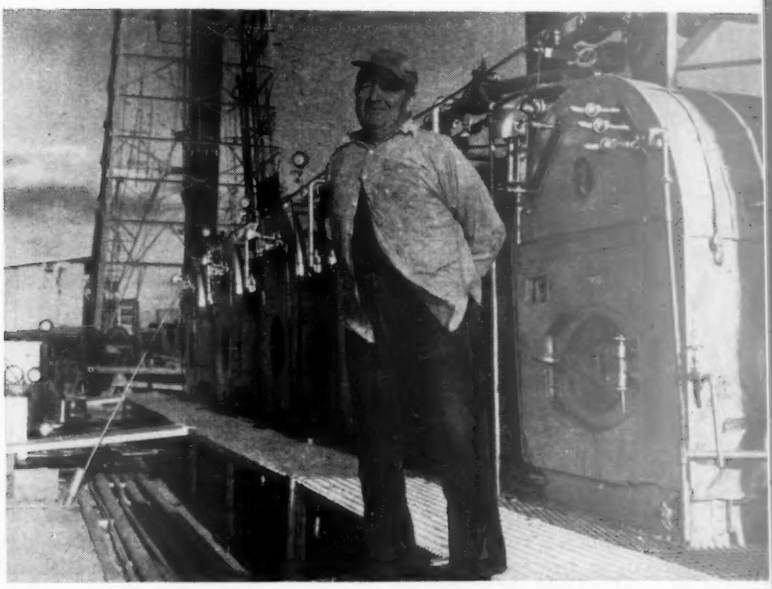


Richfield's Coles Levee A No. 67-29 in North Coles Levee field, Kern County, California.

Standing by boilers is Fred Zimmerli, fireman.



Deep Eocene Production Established

California well completed near 18,000 ft to set new deep producing record and indicate importance of formation in area

WILLIAM T. RINTOUL

A new world's record for deep production has been set by Richfield Oil Corporation in the North Coles Levee field, Kern County, California.

At 5 a.m. on December 4, 1953, Richfield completed Coles Levee A No. 67-29 on Section 29—T 30S—R 25E in the North Coles Levee field flowing at a rate of 119 bbl per day net of 42.3-gravity oil, cutting 66 per cent oil base mud, and 1,785,000 cu ft of gas.

Initial flow was through an 18/64-in. choke with tubing pressure of approximately 2000 psi.

The record-breaking well was completed for production from a total depth of 17,895 ft — 773 ft deeper than prior deepest producer.

Completion of the deep well gave Kern County its second oil record in four months. In August The Ohio Oil Company broke the world's record for deep drilling with KCL A No. 72-4 on Section 4—T 32S—R 26E in the Paloma field, 10 miles southeast of the Richfield well at North Coles Levee. The Ohio Oil Company later drilled to 21,482 ft before sticking drill pipe on bottom. Late in December, the fishing job was still in progress with no early solution in sight at Ohio's deep well.

Of more importance than the setting of a new deep production record, at least as far as the operator was concerned, was the proving up of initial production from the Eocene sand in the North Coles Levee field.

Field Discovered 1938

Production in the field, which was originally discovered in 1938 by the same operator, previously had been confined to sands of Upper Miocene age, with various sand bodies being found productive in the Stevens zone. Before completion of the deep well, the field had 138 producing wells and a daily production of about 14,800 bbl per day of high gravity oil. Production came from sands which were found in the overall interval of 8,700-10,000 ft.

As far as is known in Kern County, the world's record for deep production prior to completion of the North Coles Levee well was held by Shell Oil Company's Gonsoulin-Minvielle-State Unit well No. 2 in the Week's Island field of Louisiana. Shell Oil Company completed this well last October for 141 bbl per day and 4,300,000 cu ft of gas, flowing from an interval at 17,260-306 ft.

Deep Drilling Commitment

The operator is believed to have drilled the deep well in compliance with a commitment made in the orig-

EXCLUSIVE

One crew on Richfield's well included: Buster Stephens, driller; G. T. Hildebrand and R. N. Johnson, rotary helpers, standing, and Joseph Nelson, rotary helper, and Marion Brooks, derrickman, kneeling.

Standing by world's deepest producing well are: F. D. Dalton, relief tool pusher, and Buster Stephens, driller.

inal Coles Levee A lease with Kern County Land Company, owner of the land on which the deep well was completed. Such a commitment also is believed to have been responsible for the drilling by Ohio Oil Company of the world's deepest hole in the Paloma field, where the original lease also was taken from Kern County Land Company.

Richfield's deep well began flowing without being swabbed at 5 a.m. on the morning of Friday, December 4, and, after flowing to the sump hole a short while, was turned to the tanks. Tubing pressure rose as high as 2800 psi, dropped, then rose again, steadying later in the day at about 2000 psi. The well began to clean up soon after completion.

Net output, however, did not increase beyond the initial production figure. Two weeks after completion, the well was reported to be flowing 59 bbl per day net of 55-gravity condensate, cutting 22 per cent salt water, and 1,700,000 cu ft of gas, flowing through a 12/64-in. choke with 2020 psi pressure over the packer.

Well Now Producing

On the basis of the first two weeks' performance, operators judged the deep well to be a non-commercial producer. In spite of this fact, it seems likely that the well will be kept on production as long as possible in order to partially pay the costs of drilling it. Additional drilling in the field will depend on whether or not geologists feel better production might be obtained elsewhere in the field from the same producing structure.

Richfield Oil Corporation drilled the deep well with a company-owned steam rig that had only been used for two other drilling jobs in the last three years and with company crews. The well was drilled to total depth of 17,895 ft in one year less two days' drilling time. Four and one-half inch drill pipe was used to drill ten and five-eighths inch hole, with crews changing over to smaller drill pipe only after casing was cemented at 17,500 ft.

Conventional rock bits were used for all drilling work, while diamond core heads were used for the relatively small amount of coring done below 15,000 ft. Oil base mud was used below a depth of 9000 ft.

New Pipe Records

In the course of drilling the deep well, the operator is believed to have set several new pipe records — at least, new as far as California operations are concerned.

After spudding in to drill the deeper zone test in the fall of 1952, the operator cemented 20-in surface pipe at 1126 ft — pipe that was almost twice as big as casing usually employed for surface protection in San Joaquin Valley drilling operations.

Later the operator cemented 11 3/4-in. at 6511 ft with 3035 sacks — a record-breaking depth for casing of that size. None of the many interested oil men who traveled to North Coles Levee for the monumental casing run had ever heard of casing of that size being cemented at a greater depth.

Eighteen and one-half hours elapsed from the time that rig-up work began until the cement was in place. The operator ran the 54-lb, J-55 seamless casing in a 16 1/2-in. hole. Couplings were welded at the top and bottom for the top 1100 ft of casing in order to increase the tensile strength of the joints. Bottoms were welded while the casing was still in the operator's Bakersfield yard. Three welders were on hand at the rig to speed up welding the tops.

An expansion collar was placed in the 11 3/4-in. string so that it would be up in the 20-in surface pipe that had been set at 1126 ft. In order to lighten the weight of the cement, the operator mixed 2835 cu ft of pearlite with the more than 3,000 sacks of cement. One to one ratio of the mix resulted in a slurry weighing between 89 and 90 lb per cubic foot. Mixing required one hour and forty-five minutes.

The operator used three stationary bulkers and four cement trucks, having rigged a special manifold beforehand to take care of the set-up. Initial displacement was with the rig pumps, which handled an estimated 80 per cent, with the cement trucks finishing the job. Displacement took 40 min. Working pressures were 400 lb to 1450 lb. Final pressure was 1650 lb.

Cementing at 17,500 Ft

Prior to completing the deep well, the operator cemented 7-in. casing at 17,500 ft with 2620 sacks. Overall time for the run was 27 hours, including anticipated delay in changing lines, unforeseen trouble with one of the spiders, and a 5-hour delay given over to circulating to cool down the mud before cementing. The bottom-hole temperature was calculated to be in excess of 325 deg.

Later the operator hung 475 ft of 5-in. liner, including 395 ft of 180-mesh screen, 3 ft off bottom.

The deep well was drilled out of Richfield Oil Corporation's Northern division headquarters in Bakersfield under the direction of C. K. Curry, division superintendent. ★ ★ ★

Artificial Formation Fracturing in Southern Oklahoma and North Central Texas†

More than 30,000 treatments made in U. S.; study of 2000 reports shows that 85 per cent are considered successful

W. L. SALLEE and F. E. RUGG

Abstract

Artificial fracturing of formations to improve oil production has become a widely accepted procedure. In the few years since the process became commercial, more than 30,000 treatments have been made in the United States.

This paper is limited to a discussion of the fracturing results that have been obtained in southern Oklahoma and north central Texas. The authors had more than 2000 fracturing reports available for study. The majority of the work done in this area was in sands of Pennsylvanian age.

Production curves and tables are used by the authors to demonstrate the economic significance of the process. Of the results studied by the authors, more than 85 per cent are considered economically successful.

THE widespread and growing interest in conservation, reservoir engineering, and secondary recovery has stimulated petroleum technicians everywhere. The petroleum geologist, whose primary interest has always been in the field of exploration, has intensified his study of the methods for securing more complete reservoir data. He is becoming more closely associated, therefore, with the petroleum engineer who realizes that the exploitation of the reservoir will be more economically significant if its fundamental geological aspects are thoroughly understood.

The ever-growing necessity of finding new oil reserves and recovering them efficiently has been responsible for the constantly expanding research programs in methods of exploration and exploitation. Results obtained from these research efforts have always been interesting and in some cases bordering on the dramatic.

Strangely enough, some of the exploitation techniques widely used today were suggested, described and tried many years ago. For example, Herman Frasch and John W. Van Dyke put into practice almost 60 years ago the method of using acid to increase the permeability of oil-bearing limestones. It was not until 1932, however, that the acidizing process became commercial and accepted generally as a means of improving the producing characteristics of oil wells.[1]

The currently popular and widely used "fracturing" technique was suggested in 1935[2] and again in 1943[3] but, here again, outside of high-pressure acidizing, actual field applications and commercial development did not become significant until 1949 when a paper by Clark[4] discussed the results obtained from laboratory and field research programs. Perhaps this technique became popular over night because it suggested a way of improving the producing characteristics of oil-bearing formations not readily susceptible to the acidizing process or because the idea of "fracturing" the reservoir rock by a hydraulic process instead of explosives appealed to the well operators. Whatever the reason, it was not long before the process was being used in oil fields everywhere. The importance of the development is immediately apparent when it is known that more than 30,000 fracturing applications have been made on wells since the method became commercial less than five years ago.

In theory, this method employs hydraulic pressure to induce fractures through which formation fluids flow freely into the wells. In practice, the fracturing media, of varying viscosities, carry graded sand in suspension to act as "propping agents" that hold open the newly made fracture after release of the pressure on the fracturing fluid. Many types of fluids are being used in the process including gelled kerosine, acid/oil emulsions, refined oils, crude oils, and thickened crude oils. Apparently, washed and graded sand has become the accepted propping media.

From the standpoint of economics, the fracturing method has proved its value. In many cases "dry holes" have been converted into commercial oil producers; well investments have been saved and marginal leases, once thought to be of little value, changed into valuable properties. On every hand there is evidence of revived interest in old properties, especially where shallow sands occur as in eastern Kansas, parts of Oklahoma, Texas, eastern Ohio, West Virginia and Kentucky.

The process has also been described as an exploration tool because it has been used to convert "dry holes" into commercial producers, and in many fields where this method has been included in workover programs, recoverable reserve figures revised upward.

It is difficult to determine accurately the percentage of successful applications but a figure of 75 per cent has been used. This paper, therefore, is presented in an attempt to evaluate the fracturing process on wells in southern Oklahoma and north central Texas. Data on more than 2000 fracturing jobs in this area were available for study. An analysis of the results indi-

The Authors

W. L. Sallee

F. E. Rugg

Warren L. Sallee is development engineer for Dowell, Incorporated. His college training was interrupted by 3 years in the United States Army. Upon discharge in 1946 he entered the University of Texas, graduating with a BS degree in mechanical engineering in 1949.

Sallee joined Dowell as a junior service engineer upon graduation, and was promoted to service engineer in 1950. Since November 1952, he has been in Dowell's general office at Tulsa with the title of development engineer.

Fred E. Rugg is also development engineer in the Dowell Tulsa office. He entered Colorado School of Mines in 1942, and during the years 1943 to 1946, Rugg served in the United States Army. On his return from service he re-entered Colorado School of Mines, receiving a BS degree in petroleum engineering in 1949. He has been with Dowell since graduation and has been a service engineer at Kermit and McCamey, Texas.

†Reprinted from the November 1953, issue of the AAPG Bulletin.

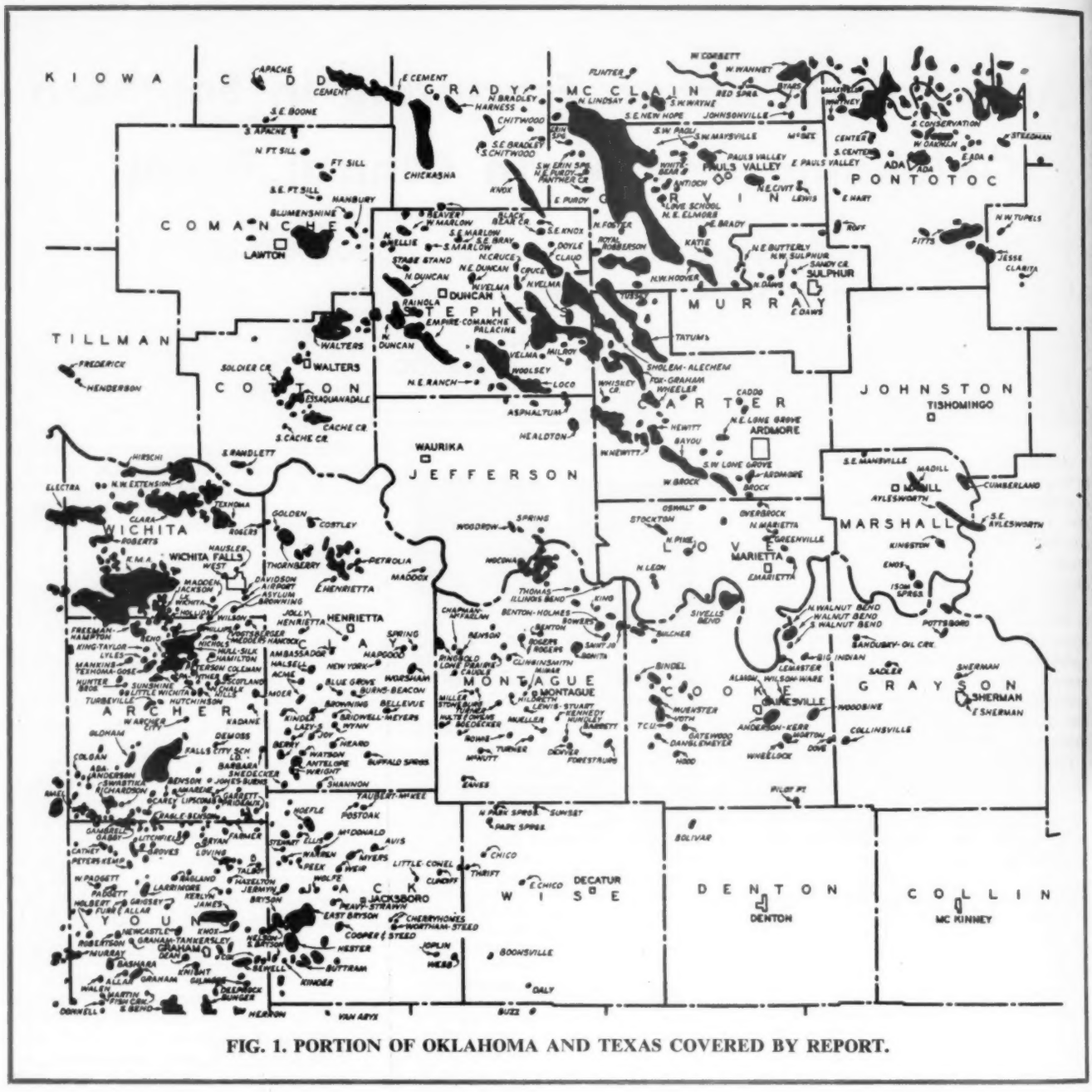


FIG. 1. PORTION OF OKLAHOMA AND TEXAS COVERED BY REPORT.

cate that success was achieved on over 85 per cent of them.

The area to which this study is confined is shown in Fig. 1. This important oil producing area contains about 35,000 wells. The Oklahoma portion with 14,000 wells accounts for approximately 50 per cent of that state's daily production. The area south of the Red River in Texas contains about 21,000 wells but accounts for only 5 per cent of the Texas daily production.

Most of the wells are characterized by having their oil produced from sands of Pennsylvanian age. The general stratigraphic sequence of the rocks in this area is shown in Fig. 2.

One of the first commercial "fracturing" treatments in this Oklahoma area was performed in 1949 on a well in the New Hope pool of Garvin County. The producing sand was the third Deese or Gibson of Pennsylvanian age. Results were outstanding; daily production of 25 bbl increased to 200 bbl.

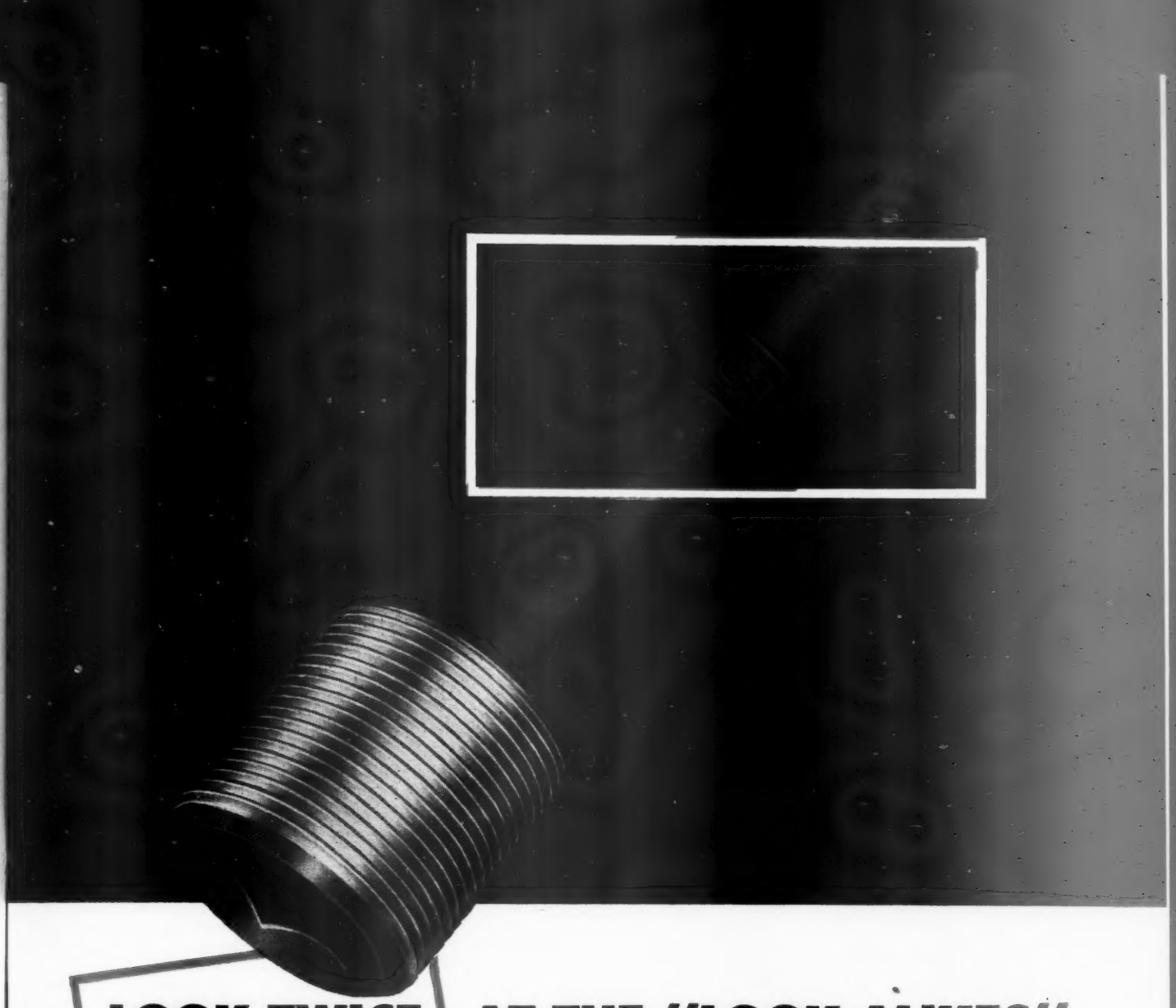
It was not until a couple of years later, however, that use of refined oil established "fracturing" as a positive force in stimulating oil production in southern Oklahoma and north central Texas. Since then, it is conservatively estimated more than 6000 fracturing jobs have been performed in this area.

Principal oil producing horizons in southern Oklahoma occur in the Springer and Deese groups. Other pay zones are found in the Simpson group and the Sycamore limestones.

The oil producing sands in southern Oklahoma generally are medium to fine grained and well cemented with lime. They are intercalated with shales and are further characterized by lensing caused by lateral gradation from sand to shale. The sands are also faulted. Thickness of the sands varies greatly but the average net for the Springer is estimated at 100 ft and for the various Deese sands approximately 20 ft each. The porosity of the Springer sands will average 20 per cent, the permeability 150 md and the connate water 25 per cent. The Deese sands have an estimated average porosity of 15 per cent, permeability 30 md, and connate water 27 per cent.

Data compiled from more than 1000 fracturing applications in southern Oklahoma are summarized in Table 1. These data are calculated on settled production, the treatments having been made about six months to a year prior to this study. Flush production figures were not used.

Fracturing jobs performed on sands of the Springer group have increased production an average of 736 per cent. Because of the large natural production



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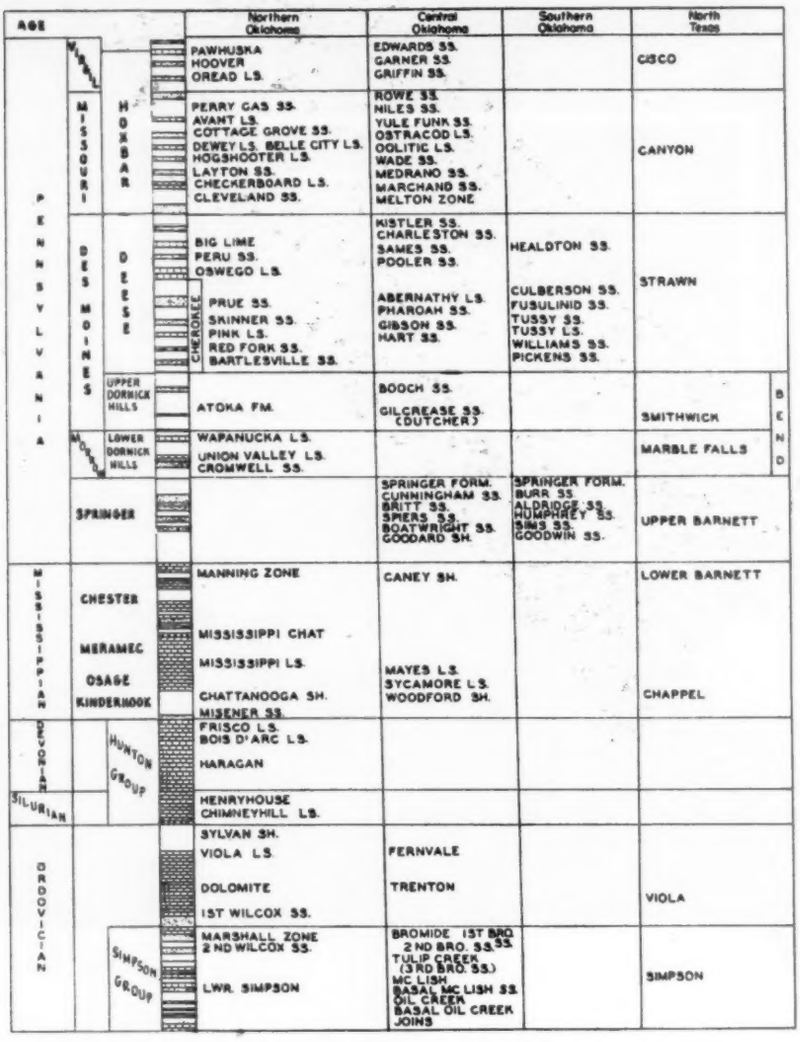

FIG. 2. MAJOR formations of Oklahoma and North Texas.

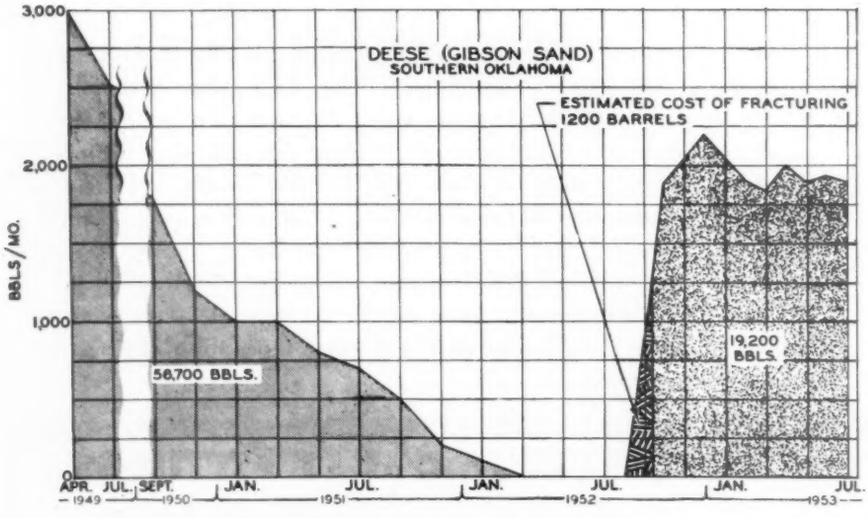

FIG. 3. TYPICAL performance record of well completed in Deese sand in Southern Oklahoma.

from the Springer sands, only 29 per cent of the treatments analyzed in southern Oklahoma are included in this study. In many instances, the Springer wells flow their allowable without stimulation.

Greatest number of wells analyzed produced from the various sands in the Deese group. Of the total wells studied, 66 per cent were in these sands. Average increase of production due to "fracturing" was 583 per cent per well.

Only 5 per cent of the results analyzed were from the Sycamore lime. Wells in this formation also responded favorably to fracturing; the average per cent increase in production was 439 per cent per well.

A typical decline curve of a Deese sand oil producer is shown in Fig. 3. Well data plotted here were selected from a large group because this well performed in a manner fairly typical of most Deese wells following fracturing. Other production figures of a more outstanding nature were available as well as some of lesser economic importance.

This well had flowed 56,700 bbl of oil during the three years following its completion in the Gibson sand. The well went dead; all attempts to place it on production failed. It was then fractured, and promptly returned to flowing status. In less than 3 weeks the well had produced enough oil to pay all costs entailed in the remedial operation. . The economic significance is immediately apparent. In little over 10 months, this well has flowed more than 19,000 bbl of oil in excess of the production required to pay workover costs.

In one part of the Golden Trend area of southern Oklahoma, 28 wells producing from one of the Deese sands have been fractured. These wells had an average cumulative production of 41,-300 bbl per well in about 3 years of productive life prior to the start of a workover program. At this time all the wells were near their economic limit. Since completion of the workover program, which included fracturing, all of the wells have flowed an average of 234.7 days with average production of 51 bbl of oil per well per day. Average cumulative production since fracturing is 11,907 bbl per well.

Another producing area in southern Oklahoma contains 15 wells in which the oil is found in a shallow Permian sand, known locally as the Fort Sill. In June 1951, total production of all these wells was 85 bbl of oil per day. Between June and September 1951, all the wells were fractured. Upon completion of this program, the combined daily production was 170 bbl. After 2 years these wells still pump 74 bbl of oil per day. The operator of the property estimated that after enough oil had been produced to pay all workover costs, there were 32,000 bbl more oil for the pipe line than would have been available had the wells not been "fractured."

The Simpson group, while productive in several places in southern Oklahoma, has not been considered in this study because of its relative unimportance as compared to the younger pay horizons. Some wells, however, producing from the Bromide sands in this area have been fractured. Generally speaking, the results obtained from the rela-

TABLE 1. Analysis of fracturing results Southern Oklahoma.

Formations fractured	% Total wells analyzed	Average % prod. increase (settled prod.)
Deese group	66	583
Springer group	29	736
Sycamore	5	439

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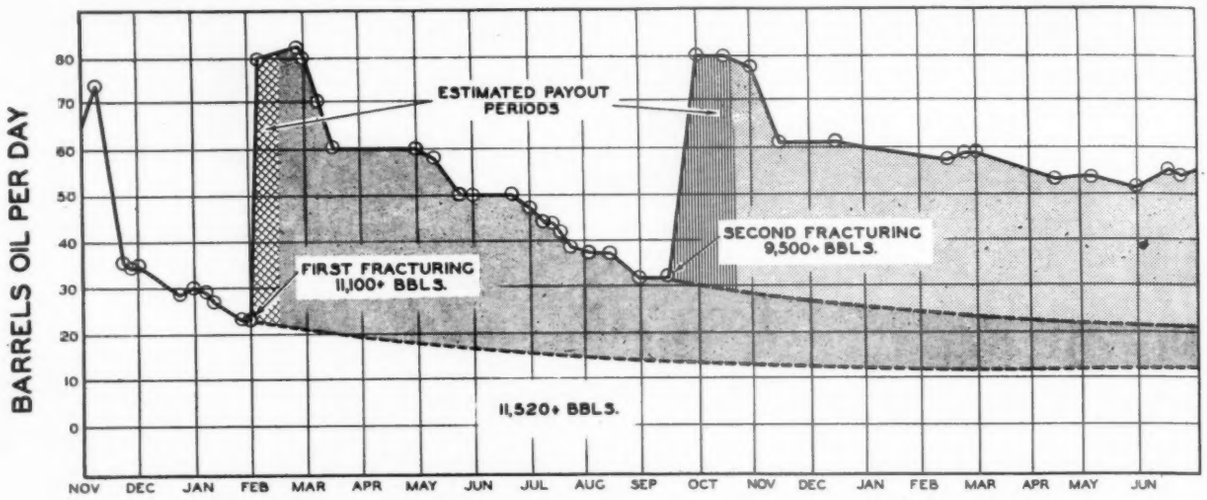

FIG. 4. PRODUCTION performance of a one-well lease in North Texas before and after fracturing.

tively few wells treated have been only moderately successful.

An analysis of the north central Texas fracturing results shows that approximately 99 per cent were from wells completed in sands of Pennsylvanian age. These oil producing formations are, for the most part, medium to fine grained, well cemented sands. The sands are further characterized by thin streaks of shale, with the exception of the lower Pennsylvania which contains some conglomerates.

Sands in the lower Pennsylvanian Bend series were the producing formations for 21.1 per cent of the wells included in this report. The porosity of these sands averaged 13.8 per cent; the permeability 62 md. Connate water content, determined from a study of 400 cores, was 29 per cent. More than half of the north Texas fracturing results examined in the Bend Formation were from well treatments made in Jack County. The oil producing formations reworked in this area were mostly composed of conglomeritic sands. The average increase in production as a result of fracturing these rocks was 743 per cent.

The oil producing sands of the Strawn series are characterized by wide variations in lithology. More than 600 wells, included in this study, were producing from various sands and limey sands in the series. A report on 400 cores from these sands showed the average porosity to be 16.3 per cent, permeability 29.7 md, and connate water 31 per cent. Acid solubility of the oil producing zones analyzed varied from less than 1 per cent to a maximum of 35 per cent. Increase in production from fracturing averaged 827 per cent per well.

The Canyon is distinguished lithologically by the presence of relatively thick, massive limestones and sandstones. Only 6 per cent of the wells available for this study were producing from the Canyon beds, and all of these were in well developed sands. The production increase from these fractured wells averaged 692 per cent per well.

Cisco sands provided 12 per cent of the well data used in this study. The porosities, generally, averaged 23 per cent. Permeability was fairly high, some being recorded above 150 md. Connate water content varied between 25 and 30 per cent on the cores studied. Wells in the Cisco that were treated responded with an average production increase of 603 per cent per well.

A production decline curve typical of the results obtained from fracturing the Strawn sands is shown in Fig. 4. This one illustrates the behavior of a one-well lease on which accurate well data were available. The well was treated twice. The percentage of increase of production for each of the treatments was respectively 173 and 103 per cent. These figures were calculated after the flush production period had passed and are lower than the average for the Strawn sands which was 827 per cent per well.

This well was completed initially for 73 bbl but by the end of the first month production had declined to 32 bbl per day. During the next 60 days the production dropped to 23 bbl. It was then fractured for the first time. Daily production of oil increased to 80 bbl. The decline during the next 6 weeks was fairly rapid while the flush production was recovered. Then the decline leveled off at 60 bbl per day. For the next six months the well produced at a rate well above the pretreatment level. It was then given a second fracturing treatment.

Prior to the first workover the slope of the stabilized decline curve was 1/3.42. After the first fracture treatment the slope of the stabilized curve was changed to 1/4.68. The amount of oil recovered as a direct result of the first treatment was more than 11,100 bbl. This oil was in addition to that expected under the original estimated decline curve. Approximately 1000 bbl were required to off-set all workover costs.

The second fracturing treatment restored the well to a rate equal to that secured from the first treatment. Flush production decline curve resembles the earlier one. The well leveled off at above 60 bbl and the slope of the stabilized curve was changed to 1/12.5; the decline curve being much flatter. Second treatment resulted in recovery of 9500 bbl of oil over that which would have been recovered normally. In this time it is estimated that 1500 bbl of the new oil were required to pay all costs incidental to the service.

This well has produced, during its 20 month life, a total of 32,120 bbl of oil. Of this amount 20,600 bbl or 61.2 per cent have been recovered due to the application of the fracturing technique.

A few jobs have been performed in Ellenburger wells with satisfactory results. The per cent increase has been 345 per cent. The Ordovician Oil Creek formation has accounted for 0.2 per cent of the fracturing in north Texas. This work has provided some interesting results; the per cent increase in production is 4125 per cent. One of the wells in this group, making only one barrel per day, increased to 80 bbl, thus accounting for the high average production increase.

The results obtained from fracturing the producing formations in north central Texas are summarized in Table 2.

The original intent of this study was

TABLE 2. Analysis of fracturing results North Central Texas.

Formations fractured	% Total wells analyzed	Average % prod. increase (settled prod.)
Cisco	12	603
Canyon	6	692
Strawn	60.4	827
Bend	21.1	743
Oil creek	.2	4125
Ellenburger	.3	345

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to determine the effects of fracturing process on various producing formations in southern Oklahoma and north central Texas. Data were available for examination on every oil producing formation that had been artificially fractured in this area. Information on methods of well completion, treating techniques, volumes of fracturing media, geological data, and production figures were available.

Generally speaking, most of the wells were completed with casing set through the producing interval and perforated opposite the various pay zones. Practically all the fracturing work was carried out under some type of packer.

Size of the treatment was between 1000 gal of fluid and 750 lb of sand and 100,000 gal of fluid and 100,000 lb of sand. The average treatment was 3000 gal of fluid and 4000 lb of sand.

In most cases the service work was completed in less than three hours including the time required to hook up and dismantle the service equipment. The shut-in time following treatment varied widely but probably did not exceed six hours.

All the fracturing media were flushed from the well bore, sometimes with a volume of oil equal to the tubing and the space below the packer. In other cases the wells were overflushed, the volumes exceeding 150 bbl. The customary procedure, however, was to overflush the system by about 20 bbl.

Variations in treating procedures and pay formation appear to have no appreciable effect upon the results obtained from fracturing in the area considered in this study. There appears to be some indication that treatments made with 10,000 gal or more of fluid and at least one pound of sand per gallon result in flatter production decline curves. More time must pass before this statement can be definitely established.

It can be concluded positively, however, that the fracturing process as used in southern Oklahoma and north central Texas is providing profitable results in most instances and is certainly stimulating new field activity that is almost sure to result in the addition of significant volumes of oil to the nation's recoverable reserves.

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4. Clark, J. B. "A Hydraulic Process for Increasing the Productivity of Wells." *Trans. AIME*, Vol. 186, 1949, pp. 1-8. ★ ★ ★

Rocky Mountain Oil Activity at New High

Oil activity in the Rocky Mountain states increased more during 1953 than in any other year in the history of the region. Drilling increased by approximately 45 per cent to a total of 3417 wells, as compared to 2357 drilled during 1952 and only 1012 during the year 1949. There were 1037 wildcat wells alone drilled in the region during 1953, more than total wells in 1949.

Successful drilling extended throughout all Rocky Mountain states. Important discoveries were made in North Dakota, Montana, Wyoming, Colorado, western Nebraska, northern New Mexico and Utah. Petroleum Information, regional oil reporting service compiling this information listed a total of 144 discovery wells drilled during the year, an increase of 48 per cent over the previous year's record. Wildcats drilled were also more successful with nearly one wildcat well out of seven a producer.

Seventeen million feet of hole were drilled for a new record in the region, with this drilling divided 27 per cent in Wyoming, 21 per cent in Colorado, 18 per cent in northern New Mexico, 13 per cent in Montana, 9 per cent in western Nebraska, nearly 8 per cent in North Dakota, 2 per cent in Utah and the balance in adjoining states.

Leasing of lands was more selective and with less volume than in previous years.

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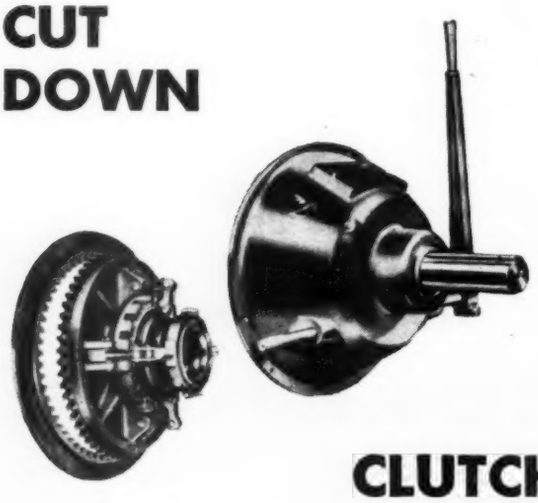

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LOCATING ZONES OF FRACTURE

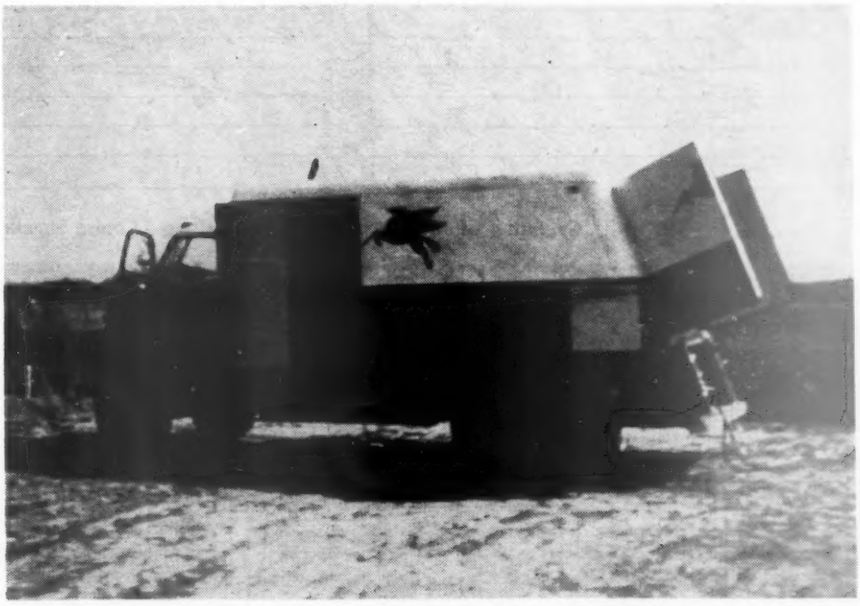
Magnetic iron oxide injected with Hydrafrac fluid provides tool for determination of points of entry

A. A. STRIPLING

In a number of wells drilled in the Spraberry trend of West Texas, magnetic iron oxide, mixed in Hydrafrac gel, has been used as a tracer to mark the fractures into which the gel has been squeezed. This marking is detected by a recently developed magnetic susceptibility logging tool. A comparison of logs made before and after Hydrafrac delineates fractured zones.

The new logging tool also records an induction conductivity log simultaneously with the magnetic log. A comparison of the resistivities recorded before and after Hydrafrac disclosed zones in which the resistivity has been increased by the Hydrafrac operation. This increase in resistivity is interpreted as indicating zones in which conductive formation water has been displaced by the non-conductive fluids used in the Hydrafrac operation, and is therefore a qualitative measurement of permeability.

The use of magnetic tracer in oil-base drilling fluid may provide a means of marking permeable zones in wells in which conventional electric logs can not be run. Experiments are now being conducted to test this application of magnetic logging.



EXTERIOR view of Magnolia's combination hoist and instrument truck.

The Author

A. A. Stripling has been employed at the Field Research Laboratories in Dallas, Texas, by Magnolia Petroleum Company since 1947. His main interest has been in the development of new logging methods. He was employed for several years by the U. S. Weather Bureau and graduated from the University of Houston in 1941. During the war he served in the Navy as a navigator in the naval air transport service and as an instructor in navigation and meterology.

A DESCRIPTION of the recently developed magnetic and resistivity logging instrument appeared in the January, 1952, issue of *Geophysics*[1]. The sensing element of the instrument is a short coil which is coupled to the formation by induction. Both conductivity and magnetic susceptibility of the formation being logged produce effects which can be separated and simultaneously recorded as two logs. Conductivity is the reciprocal of resistivity, and since resistivity is well established in usage, induction conductivity is commonly interpreted in terms of resistivity.

The oil industry is familiar with resistivity logs, but magnetic susceptibility is new. This is not the same phenomenon as permanent or remnant magnetism. It is, on the contrary, a measurement of the ease with which a given substance can be magnetized when placed in a magnetic field. Since pure iron has the highest susceptibility of any element, the variation in susceptibility of various rocks depends primarily upon the amount and kind of iron minerals in them.

The magnetic log will correlate with a gamma ray log in many wells because, by coincidence, formations containing radioactive material usually contain iron compounds. Limestones, dolomites, and clean sands are low in susceptibility and in radioactivity, while shales and igneous rocks are usually high in both. This is not a hard and fast rule, however, and exceptions occur when sands contain magnetite or other iron compounds but no radioactive material, or where the reverse occurs and the rocks contain radioactive compounds but no iron minerals.

Just as radioactive material can be used as tracer for the gamma ray log, so iron compounds can be used as a

[1]R. A. Broding, C. W. Zimmerman, E. V. Somers, E. S. Wilhelm, and A. A. Stripling, "Magnetic Well Logging," *Geophysics XVII* (January 1952) 1-26.

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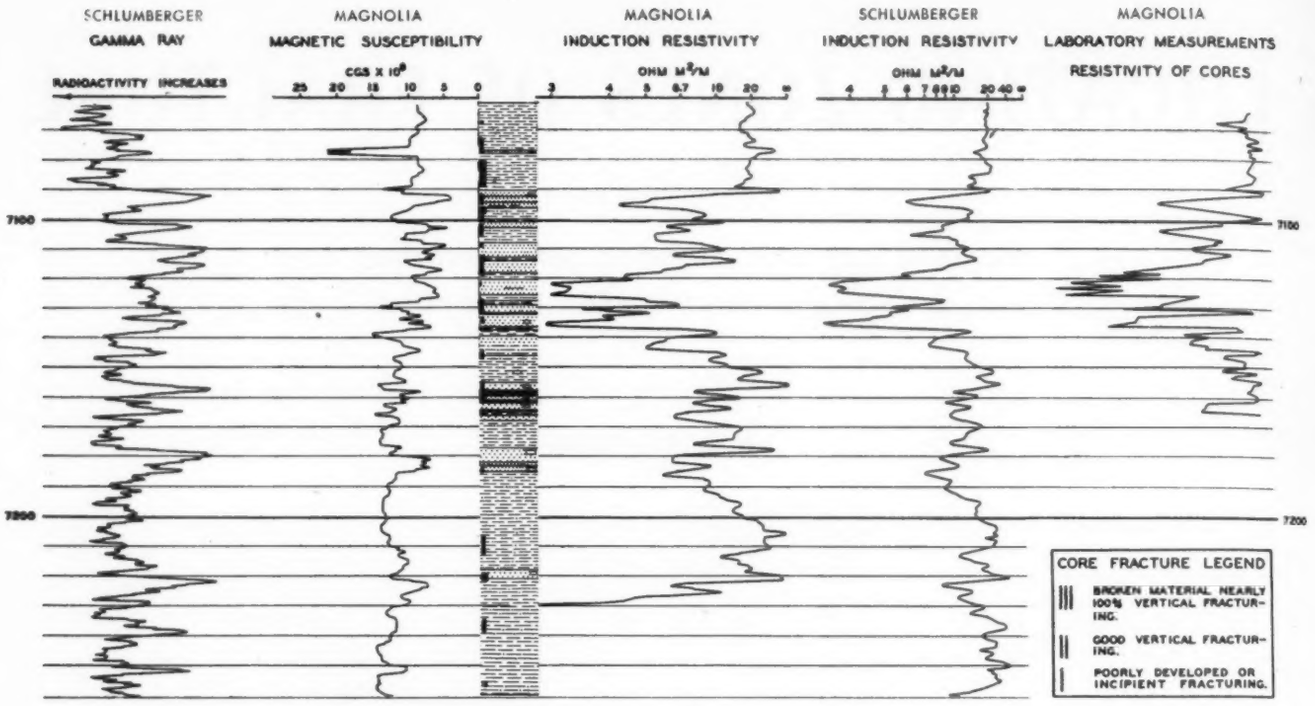


FIG. 1. Correlation of logging methods in Spraberry, Louise Shackelford No. 8, Tex Harvey field.

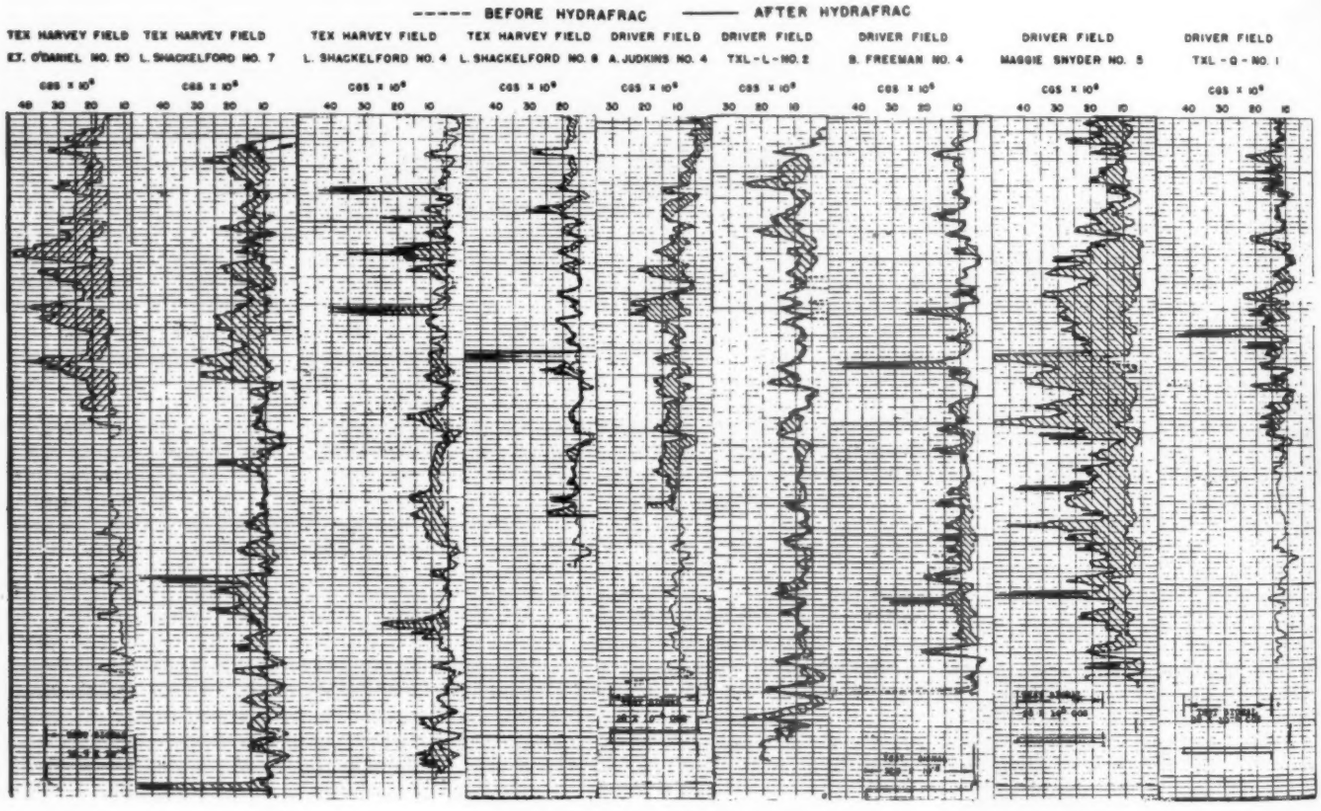
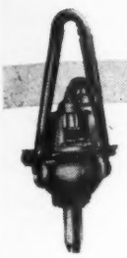


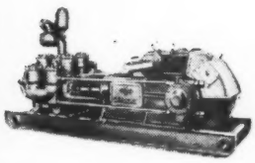
FIG. 2. Magnetic susceptibility logs.

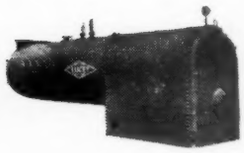
tracer with the magnetic log. The best tracer is powdered magnetite. It is readily available and inexpensive, and requires no special handling. Radioactive logs can be run either in open or cased holes, but the magnetic log is limited to the open hole. It is independent of the drilling fluid and will log in air-drilled holes containing no drilling mud.

Spraberry Logs In Midland County, Texas

The Spraberry is mostly shaly siltstone with occasional dolomitic or calcareous beds. Permeability is very low, and commercial production is apparently dependent upon a system of vertical fractures which provides extensive drainage area for each well. In order to utilize this drainage system the fractures are extended and widened by hydraulic pressure. Black iron oxide was added to the gel along with the sand







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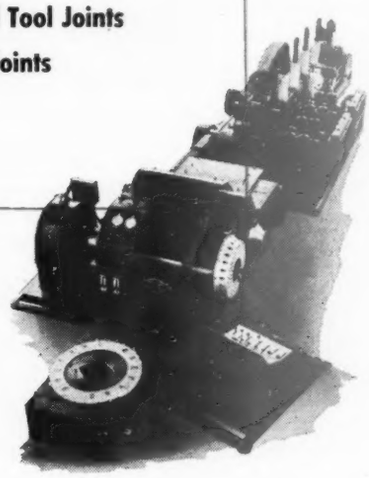

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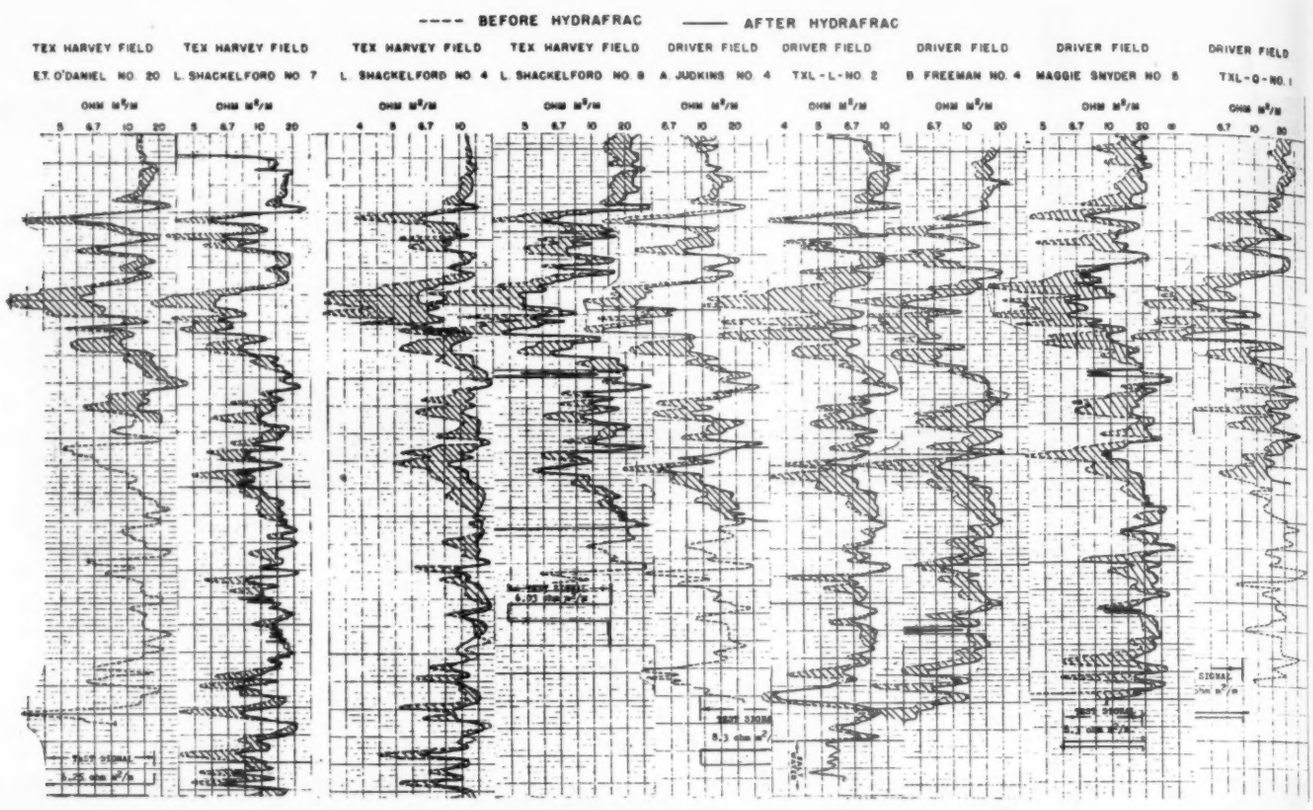

FIG. 3. Induction resistivity logs.

which prevents the fractures from closing when the pressure returns to normal. The purpose of the work described here was to determine the extent of the fractures after Hydrafrac. Well locations are shown in Fig. 4.

Fig. 1 shows logs of the Louise Shackelford No. 8 just after the section was drilled in with oil and before Hydrafrac. Gamma ray and magnetic logs are on the left. The gamma ray log has been drawn with increasing radioactivity to the left so that it corresponds to the magnetic log. Good correlation between the logs is evident except at 7077 ft. Here, a dolomitic siltstone layer contains siderite, an iron carbonate mineral which increases susceptibility without increasing radioactivity. Very thin beds of high susceptibility are always "dog-eared" as shown here because the ends of the coil in the logging instrument are more sensitive than the center, and as the coil travels up the hole past a thin bed each end of the coil produces a maximum signal. This is not true of the resistivity log made at the same time, because, in measuring resistivity, the center of the coil is more sensitive than the ends of the coil.

To the right of the core description are three resistivity logs. At the time the logs were run, the fluid in the hole was oil with about 30 ft of salt water in the bottom. These two logs are in good agreement except in the salt water portion of the hole where the non-focused Magnolia log records the low resistivity of the salt water. The log on the extreme right was drawn from resistivity measurements on individual cores.

It is interesting to note that in the Spraberry the shale is higher in resistivity than the calcareous siltstone. This particular shale is compact and low in water content. The siltstone beds have porosities of about 10 per cent which are 60 to 80 per cent saturated with salt water. The relationship between the resistivity curve characteristics and formation lithology and fluid content was discussed by Lytle and Rieke[2] in a recent issue of *The Oil and Gas Journal*.

The amount of fracturing visible in

[2]W. J. Lytle and R. R. Rieke, "Well Logging in the Spraberry," *The Oil and Gas Journal*, Dec. 13, 1951.

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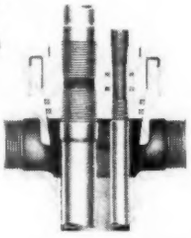

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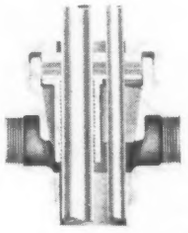

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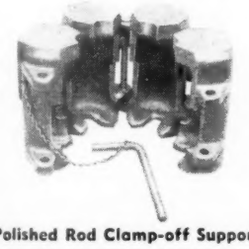
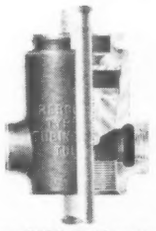


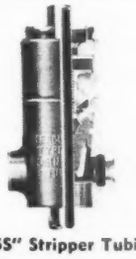
Polished Rod Clamp-off Support

NEW

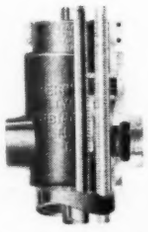


Type "J5" Tubing Head

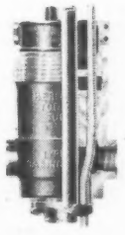
NEW



Type "J5S" Stripper Tubing Head



Type "J5R" Tubing Head



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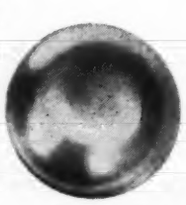

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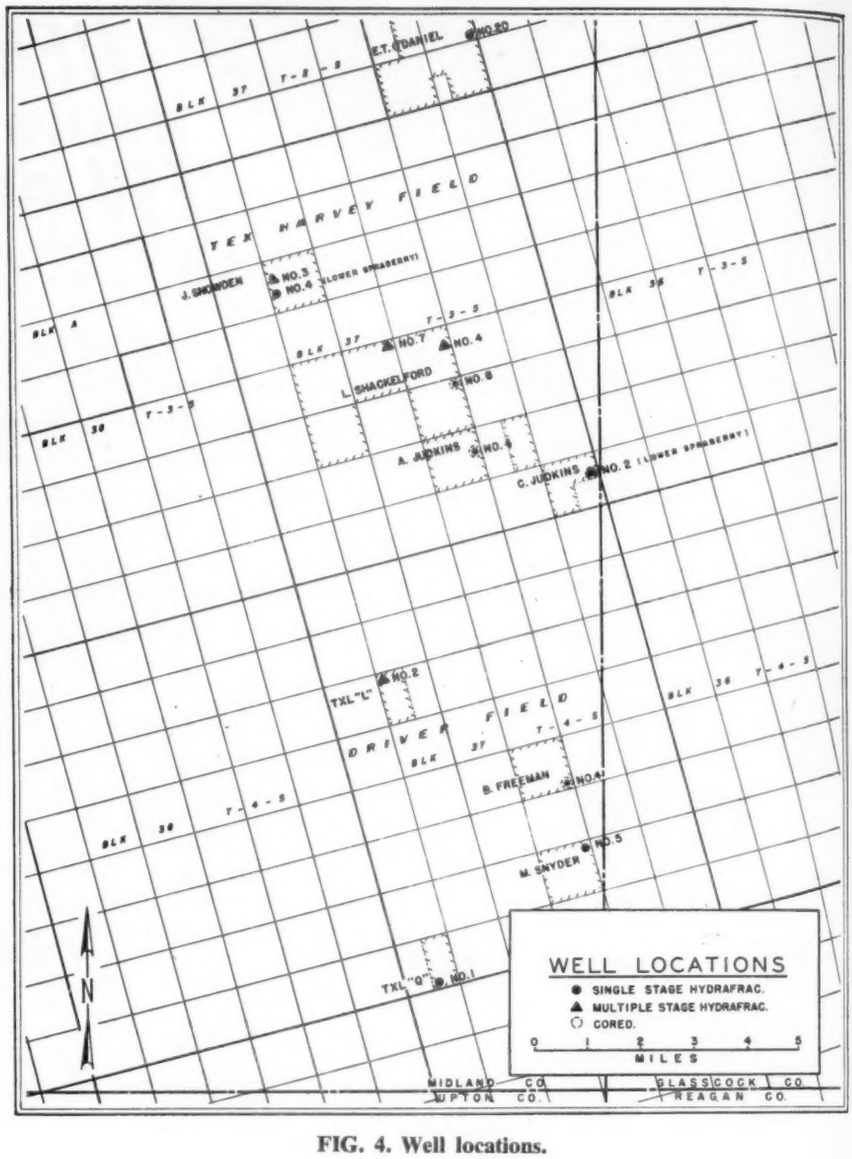
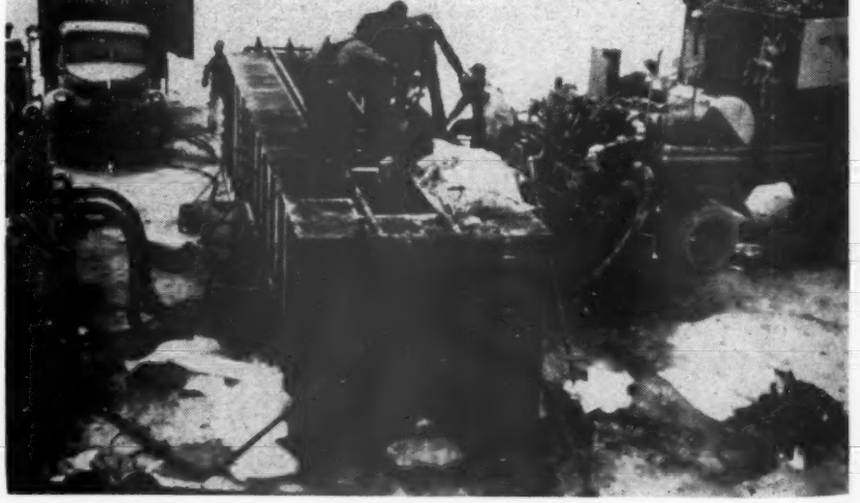


FIG. 4. Well locations.



PREPARATION of kerosine, neogel, and sand solution used in fracturing. Magnetic iron oxide is added prior to injection.

the cores is indicated by short vertical lines at the left of the core description. Three vertical lines indicate that the core material was broken into small pieces, two lines indicate that the core was split vertically when removed from the core barrel, and one line indicates a solid core with marks indicating possible fractures.

Magnetic Logs After Hydrafrac

Magnetic logs of eight upper Spraberry wells are shown in Fig. 2. Wells are lined up in a general north-south direction from left to right. "Before Hydrafrac" logs are shown as broken lines and "after Hydrafrac" logs are solid lines. Cross-hatching indicates the sections of the well where the "after Hydrafrac" logs showed marked increase in magnetic susceptibility over the "before Hydrafrac" logs. The increase could only have been caused by the Hydrafrac gel carrying tracer material into fractures. Therefore, fractures in the formation corresponding to cross-hatched sections on the logs have been opened up by the Hydrafrac process.

Concentration of tracer material was kept at five pounds per barrel of gel in order to keep the logs on a comparable basis.

The Hydrafrac treatment was carried out in two different ways. When this experiment was begun it was the practice to divide the pay section into six zones and to treat each zone in turn, beginning at the bottom. Thus, about 30 ft of section was treated at a time. It often happened that the packers used in this process got stuck and an expensive fishing job was required. Later, the practice of treating the entire pay section at one time was adopted. This is a more efficient method. Its effectiveness can be seen in Fig. 2 by comparing the logs of O'Daniel No. 20, Shackelford No. 8, Judkins No. 4, Freeman No. 4, Snyder No. 5, and TXL Q No. 1, which were Hydrafraced in one stage, with those of the Shackelford Nos. 4 and 7, and TXL L No. 2, which represent multistage Hydrafrac operations.

In order to run logs after Hydrafrac, it was necessary to clean out the wells. In some cases the logging tool would not go to bottom even after a well had been cleaned out. If the tool failed to reach bottom after a second clean-out operation, no further attempts were made to log this well. This difficulty provided an opportunity to re-log the upper sections of four wells after Hydrafrac. Results are shown in Fig. 5. The broken line log in this figure is run No. 1 after Hydrafrac and the solid line is run No. 2.

These logs show fairly good duplication. If the tracer had been merely plastered on the walls of the wells and

The New Pacific

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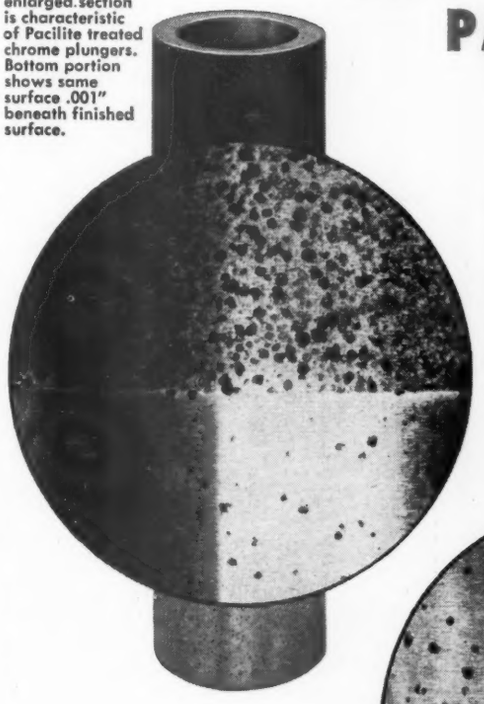
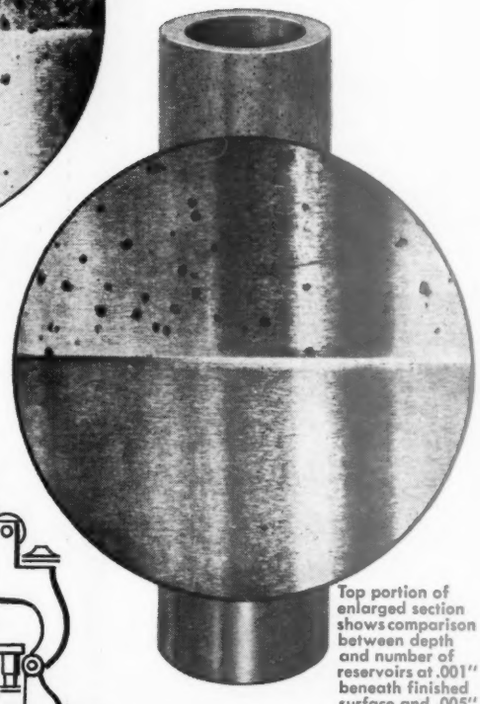
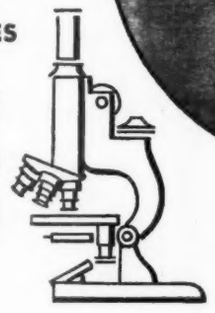
FOR DEEP OIL WELL PUMPING...

The number of surface reservoirs on top portion of enlarged section is characteristic of Pacilite treated chrome plungers. Bottom portion shows same surface .001" beneath finished surface.





HAVE MILLIONS OF MICROSCOPIC PORES *that actually soak up lubricants!*



Top portion of enlarged section shows comparison between depth and number of reservoirs at .001" beneath finished surface and .005" where controlled etching has eliminated reservoirs.

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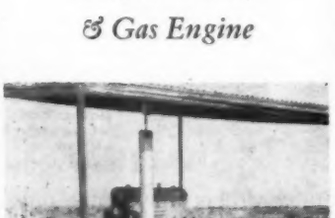

Wichita County, Texas

SURVEYS
ESTIMATES
DESIGN
INSTALLATION
SUPERVISION

PETROLEUM ENGINEERS
CABLE ENGINEERING
WICHITA FALLS, TEXAS

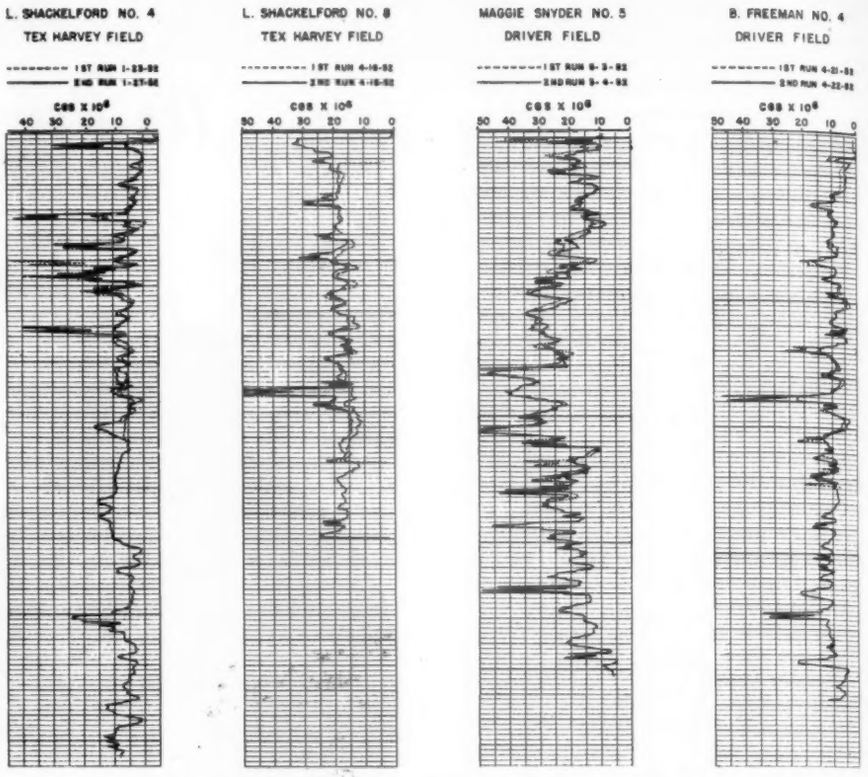

FIG. 5. Duplication of susceptibility logs after hydrafrac.

was not actually back in the fissures in the formation, it would have been removed by the clean out. Poor duplication of the logs would have resulted. One major discrepancy occurs in L. Shackelford No. 8. This has been attributed to junk left in the hole after the first clean out.

Fig. 3 is a panel of resistivity logs in the same sequence as the susceptibility logs of Fig. 2. The "before Hydrafrac" logs correlate quite well across the profile, indicating a general continuity of stratification. The "after Hydrafrac" logs also correlate, and zones where the resistivity has been increased markedly by Hydrafrac operation can be followed from well to well across the field. These zones have been cross-hatched on the figure. This increase in resistivity is believed to be due to the displacing of conductive formation water by non-conductive gelled kerosine.

Other uses for the iron oxide tracer have been considered. One is the use of a small amount of tracer in oil base muds. Any mud cake formed in front of permeable zones would contain a concentration of the tracer. A magnetic susceptibility log would therefore be expected to indicate the permeable zones and would be of great value since conventional logs cannot be run in oil.

Conclusions

The magnetic log and tracer combination described here is now available to the industry. Two commercial well logging companies have pilot model tools in the field. The iron oxide tracer is a stable, non-corrosive mineral that is chemically inactive. It thus has an advantage over radio-active tracers that must be handled carefully.

Spraberry logs showed that the vertical extent of the fractures after Hydrafrac was greater than might have been predicted from examination of the cores. This indicates that sections of the formation are split vertically by the process. Depth of fracturing is not reliably indicated by the logs. There is little correlation across the field in the "after Hydrafrac" magnetic logs. This means that the fracturing is random.

The resistivity logs after Hydrafrac show excellent correlation across the field and zones containing movable conductive fluids can be projected from well to well.

Prior to the running of these logs, there was considerable concern over the possibility that in the single stage Hydrafrac method, one fracture might open up and take all of the gel and so prevent other fractures from being extended. Logs show, however, that insofar as the Spraberry is concerned, fracturing is about the same whether by single or multiple stages. The single stage method is much more efficient and completion costs have been reduced through the decrease in rig time required to put the wells on production.

* * *

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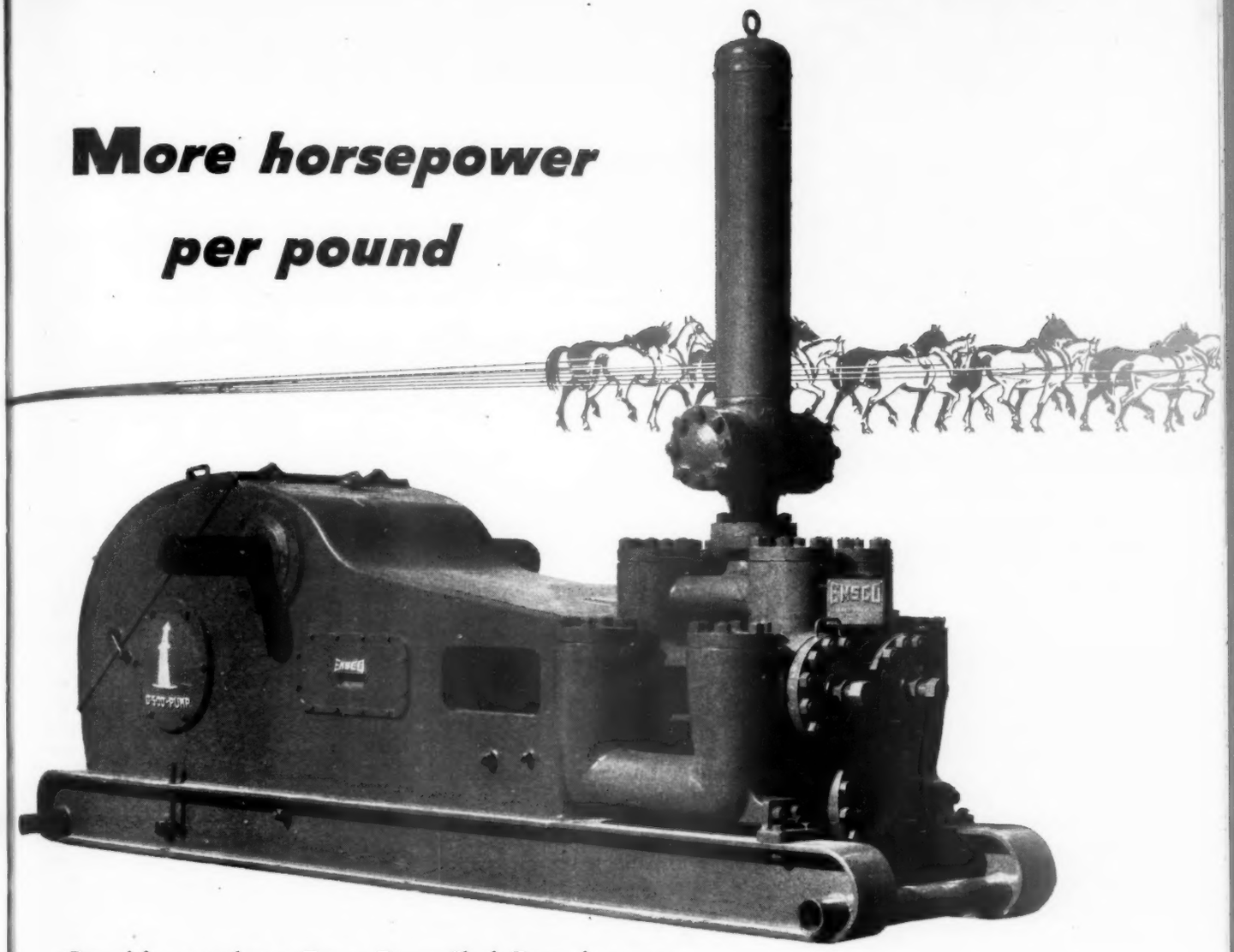

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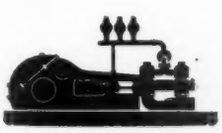
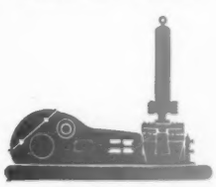
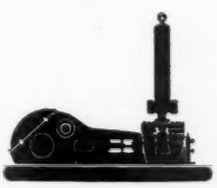


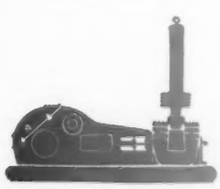
D-850: Hp. input
850 @ 60 rpm.



D-500: Hp. input
500 @ 65 rpm.



D-300: Hp. input
300 @ 70 rpm.



D-175: Hp. input
175 @ 75 rpm.

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California Brings in First New Tidelands Production

Monterey Oil Company finds oil 1900 ft offshore after state recovered ownership

WILLIAM A. MOSES

First tidelands oil brought up from Newport Beach-owned offshore waters is exhibited here by Jim Bosley, roughneck of Santa Maria, who worked on Monterey's well.

OIL history was made and is still being made in Newport Beach, California, where a relatively new firm brought in the first tidelands black gold since the federal government returned ownership to the states. The first well, a Monterey Oil Company producer, came in at about 4445 ft and 1900 ft offshore.

Monterey's first rig into Newport Beach-owned tidelands claims the distinction of being first with offshore oil. Although a comparatively new company, it's a direct descendant, in a manner of speaking, of Jergins Oil Company. Like most firms these days, Monterey has Texas "kinfolk" — Humble Oil and Refining Company — in the Newport tidelands operation.

Santa Maria Drilling Corporation's crews sank the first hole last fall after Monterey's vice president, Ernest E. Pyles, finished long preliminary negotiations with the city, and after the company had made individual sub-surface easement agreements with a number of West Newport property owners. Neither the city nor the residents were as eager to settle as you might think.

Monterey, formed after an Eastern syndicate bought out Jergins, inherited the now famous Elliott Contract or Elliott Lease. Oilman Walt Elliott, prominent ocean sailing skipper of Long Beach and Newport, had obtained the document years before from the City of Newport Beach.

EXCLUSIVE

Before any drill could start whipstocking into the city-owned tidelands, of course, there was the waiting period to see what the Eisenhower administration could and would do for private enterprise drilling in state-owned tidelands. When the federal light turned green in the black gold offshore search, Pyles had pacified the citizens affected and Newport's historically hard-to-please council.

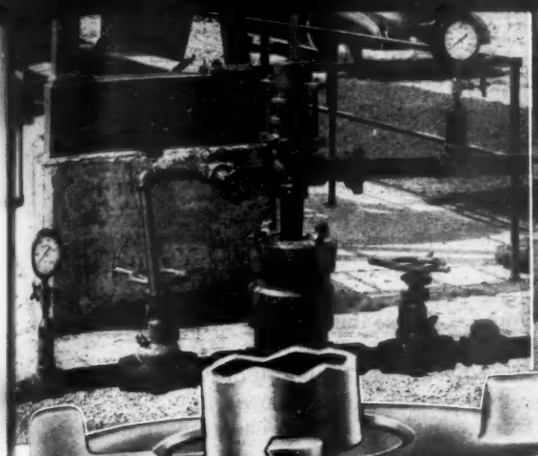
The latter gave him order to drill

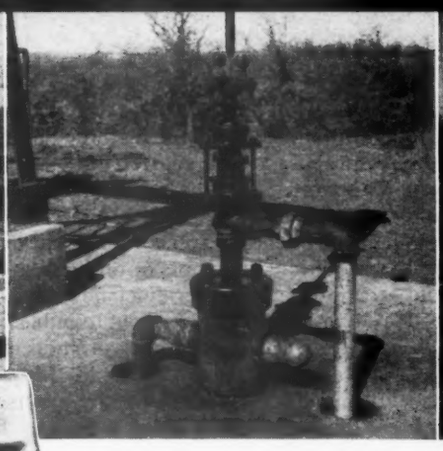
R. L. Patterson, former Newport Beach city engineer, Walt Elliott under whose original Elliott contract tidelands drilling was permitted by city, Ernest E. Pyles, vice president of Monterey. Hidden by Pyles is J. D. McKenney, drilling super.

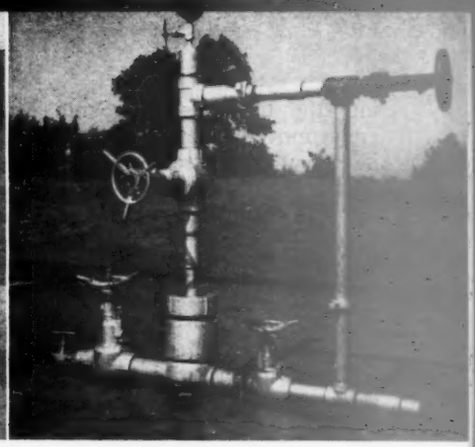
Making up slotted line are these roustabouts at Monterey Oil Company's Newport Beach drillsite. First length of pipe for next day's successful test has gone into hole.

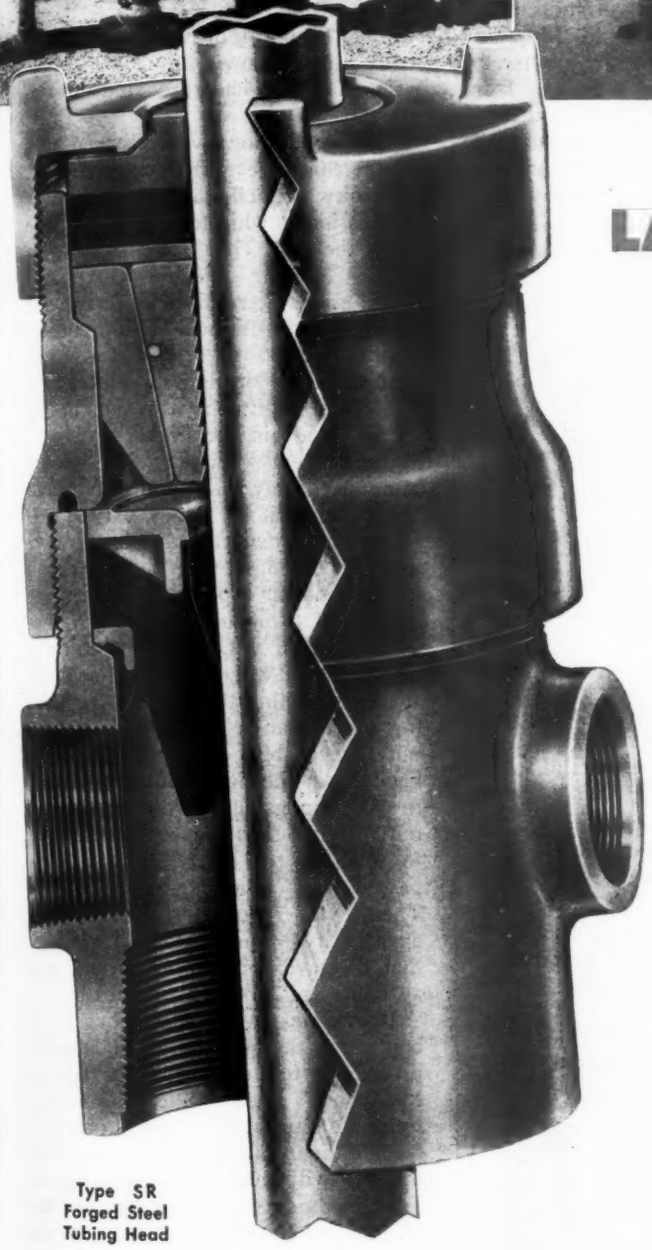
— (Newport-Balboa Press photos by Robert F. Willmes).

XUM









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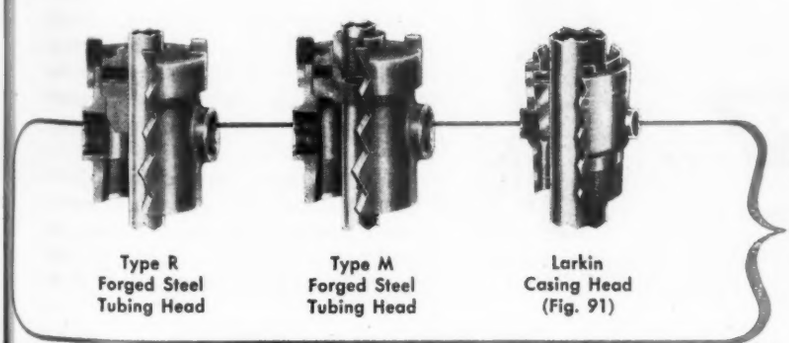

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Type M
Forged Steel
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Larkin
Casing Head
(Fig. 91)

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into the tidelands and Santa Maria crews moved their portable derrick to its site at 58th Street inland from the Pacific Coast Highway. They began drilling September 23, 1953, and townspeople who owned no lots affected by the lease but who opposed any petroleum operation that would mar Newport Harbor's beauty hoped the well would be a duster.

There's a reason for this. Newport Harbor has nearly 500 boats berthed in its public and privately owned slips. It is reputedly the finest yacht harbor in the nation. As this is written, a City Board of Freeholders election has just been held and 15 winning candidates now will be under heavy civic pressure to limit oil drilling when they draft the proposed city charter. The city has operated as one of the sixth class.

Oil in Newport is a mixed blessing as indicated. Some folks believe any additional attempts of oil firms to lease more acreage for tidelands whipstock operations should be put to public vote.

Even when the council and citizens were finally agreeable to Monterey launching operations, the course of tidelands oil pursuit was far from peaceful. Trouble dogged the drillers. Cave-ins and the like plagued the Santa Maria boys who for a time logged about 280 ft on a good day.

When they had drilled to about 7200 ft more trouble slapped at them. While fishing for tools, they keyseated. That was the first week in November. A week passed as bad luck attended the the operations. At the 2200-ft level, a shoe became lodged across the hole. The crews continued to fish but in doing so they whipstocked in a new direction.

The fishing tool was lost, apparently sliding down the 7200-ft hole after the crews had recovered most of the pipe.

Then operations were plugged back to the 900-ft level and cemented off. The city council gave the company permission to whipstock a second hole from the first. That one proved to be good.

Oil sands were found. Tests were made in a 170-ft zone. With a vertical depth of 3900 ft, J. D. McKenney, Santa Maria's drilling superintendent, tested the 170-ft zone with 7-in. casing being placed in the hole.

To prevent a public "flop," Pyles announced only that findings bore out the belief that oil sands existed offshore; but he maintained a conservative attitude. Things were tense around town, optimists expecting a gusher.

The oil came in December 9, but as an anticlimax. Only a bucketful was above ground when the sand line cable snapped, lashing the air and frightening more than a hundred spectators, but irrevocably dropping the swab back down the hole. McKenney, true to his responsibility, shouted, "Look out!" in time for those hanging around to scamper for safety. Several days passed while swabbing was resumed. Then Pyles reported to the city oil agent, City Manager John J. Sailors, that 20 gravity oil had been found and at the rate of 250 bbl or so per day.

By the next week, December 17 to be precise, the historic tidelands well's production fell to 100 bbl per day. So McKenney's crews pulled the sucker rods and pump and hauled out perforated liner preparatory to washing the well with mud acids and solvents. This operation was hoped to make the oil flow better after going back on the pump. Actually, the well apparently did not respond as the daily run as of December 23 still was said to be 100 bbl.

Simultaneously, however, Santa Maria crews were in process of moving tankage in the vicinity of the rig so the next drillsite for Monterey's second tidelands well — only a few feet away — could be made ready.

Word was passed around the drillsite the day the well came in that a lower formation may have been discovered with the new producer. The formation reportedly is middle Miocene. ★ ★ ★

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OTHERS PENDING

6665

Can the oil industry produce again as much oil from present producing fields? Here are the fundamentals for this achievement in

PRODUCTION MAINTENANCE

CHARLES A. BREITUNG

IT is not the intention of the author to attempt to indicate that there is anything very new to be discussed in the topic of production maintenance.

There are certain basic considerations that can be noted and emphasized.

Let us outline them.

Whenever a new oil or gas reservoir has been discovered, by reason frequently of sound geological and geophysical coordination, it then becomes the assignment of the producer to work out a program of development that can accomplish the best production methods in order to obtain the largest volume of ultimate recovery of hydrocarbons present.

A detailed and comprehensive study of the characteristics of the reservoir from the available well data then becomes logical.

An operator risks capital in an attempt to find a reservoir capable of producing oil and gas in sufficient volumes to return the investment and allow a good profit for the attendant risks. It has recently been stated by *Steelways Magazine* that only one well out of 16 develops an economic oil or gas reservoir.

With the odds definitely small, the oil industry is warranted in attempting to get the greatest recovery possible from the reservoirs that already have been discovered.

It is at this point, at the outset of field and reservoir development, that sound reservoir engineering, coupled with geological facts and interpretations, should work out a progressive program that will set up a pattern to extend over the productive life of the reservoir. Such a program is obviously subject to changes as the economics of the industry shifts emphasis on the various operating costs involved.

A conservation program that will insure the greatest ultimate recoveries of the hydrocarbons present requires the teamwork of the operating men in management and on the leases, the reservoir engineers, the petroleum engineers, and the geologists who worked up the contours and reservoir limits in the first place.

The Author

Charles A. Breitung is an oil and gas consultant with offices in Austin, Texas. He attended St. Ignatius College, Cleveland, Ohio; Wittenberg College, Springfield, Ohio, and University of Michigan. He also received an honorary doctor of science degree from Laval University in 1945.

Breitung was an officer and director of E. N. Breitung and Company and various enterprises from 1919 to 1922. In 1922 he became an oil and gas consultant and has practiced in Louisiana, California, Oklahoma, and Texas. He is also an oil and gas producer.

Production maintenance, as we have called it, therefore involves a study of reservoir conditions to get as accurate an idea as is humanly possible of the various natural forces at work, perhaps three miles or more in depth in the earth. It requires vision and creative imagination to approach a proper analysis of the factors that will help recover the hydrocarbons in place.

Gas expansion pressure, or hydraulic pressure, as we know, provides the lifting force that brings the hydrocarbons to the surface.

The study therefore requires ways and means of conserving and supplementing these lifting forces.

The mixture of hydrocarbons that we call oil or petroleum, are colloids when in the liquid phase, and the production of these colloids, or "substance ordinarily regarded as insoluble, in the form of particles so small as to be indistinguishable to the eye, which remain suspended indefinitely in a suitable medium," is a study in physical chemistry. Chemical as well as physical and mechanical controls are essential in the recovery of these hydrocarbons.

We can remember that nature, as a rule, placed these hydrocarbons in the porous spaces of sandstones or limestones, together with the saline waters of the prehistoric seas which had much to do with the original deposition.

Chemical controls are therefore of vital consideration in the proper production patterns of individual reservoirs and the individual and individualistic wells in the reservoirs. Such problems as the control of reservoir fluids and the control of particle sizes of the non-colloidal matter entrained in the reservoir, as well as the control of the weak corrosion promoting acids, are all matters for technical and economic study.

Unless the program is sound in its economics, and permits a reasonable return for the risk involved, it is academic in its present aspect, albeit the situation can change as the products that are fabricated render the hydrocarbons that form the basic raw material, become more valuable.

The oil and gas industry has been required to spend vast sums on research and on equipment which will and have produced better drilling and production methods. These improvements will still go on.

There are many items which require clarification, if our thinking on good production practices is to reach higher levels of efficiency and greater volumes of recovery. An orderly pattern of production will require the full cooperation of all operators in a field, and the reservoirs in the field, and the formation of permanent engineering, geological and operating committees, all working in harmony, with a complete regard for the rights and equities of everyone concerned, producers and royalty owners. Unitization can be of great service in many instances; at the very least, a workable understanding among the operators can be arrived at which will bring about the best results for all. Too frequently a minor tempo-

rary advantage in a reservoir can work toward irreparable damage done to the reservoir. Such a policy is not good business, and the general public interest becomes immediately involved in the situation. An operator who attempts to sacrifice the general welfare of a reservoir for his own temporary advantage can be summarily dealt with in perhaps a critical manner.

The day of the pirating of and the despoiling of our natural resources has long since passed, as something to which technical men could only voice objection.

There is one thing that we as technical men, men of good will, can do as a further contribution to the industry, and that is to discuss in harmony and fairness, our problems, without magnifying troubles and distorting facts. The buccaneer and the medicine man has no place in the industry and a solid wall of public opposition will drive him out, and keep him out.

There have been honest differences of opinion regarding technical theories and methods; there will likely continue to be these differences, and the developer of new ideas must patiently persist in an attempt to demonstrate their correctness.

Production maintenance requires as a fundamental principle of approach to any problem a free interchange of ideas and a generosity of sharing methods which can lead to a better way of doing the job, and we all have our part and inevitably we are able to obtain our share of the rewards for our labors.

Some of the new ideas that are now being explored by competent research and investigation include such approaches to reservoir control as the building up of sufficient pressure and temperature as to transfer into the single gaseous and vapor phase all of the hydrocarbons present in the reservoir. Field experimental work indicates much better recoveries when the hydrocarbons have been so handled. To be sure, the geological conditions of the reservoir must be fairly well defined. The subsurface vessel must be free from possible leakage.

The work being done, with mathematical definition, on such phases as the observation of the so-called skin effect of the producing formation at the well bore will undoubtedly assist in a better understanding of production controls, and well potentials.

So will the studies being made on holding particulate matter, such as fine silts and sands, in suspension, through chemicals, by colloidal means.

Likewise the studies on controlling the swelling of clays and bentonites, which clog the pore space of sandstones and limestones, will permit positive recoveries of oil and gas which in the past have been often interfered with or even permanently stopped.

Thus it can be observed that the more thorough are these studies of reservoir conditions and characteristics, from the initial development stage, the larger will be the volume of ultimate recovery and the less expensive will be the program.

The use of a material balance study of the reservoir will give a very close check on the hydrocarbons originally in place in the reservoir, and this estimate of reserves will serve as a definite check of an orderly program for the future development and depletion of the reservoir. These studies are the particular work of the reservoir engineer, aided indeed by accurate geological data.

The industry has the challenge before it of trying to produce at least again as much oil as has been produced up to this time from the reservoirs already discovered and in productive operation.

To paraphrase from Kipling, it will take the everlasting teamwork from every blooming soul to do this job. The men on the leases have the "know what," the technical men have the "know why," and the administrative forces have the "know how" and "how much." * * *

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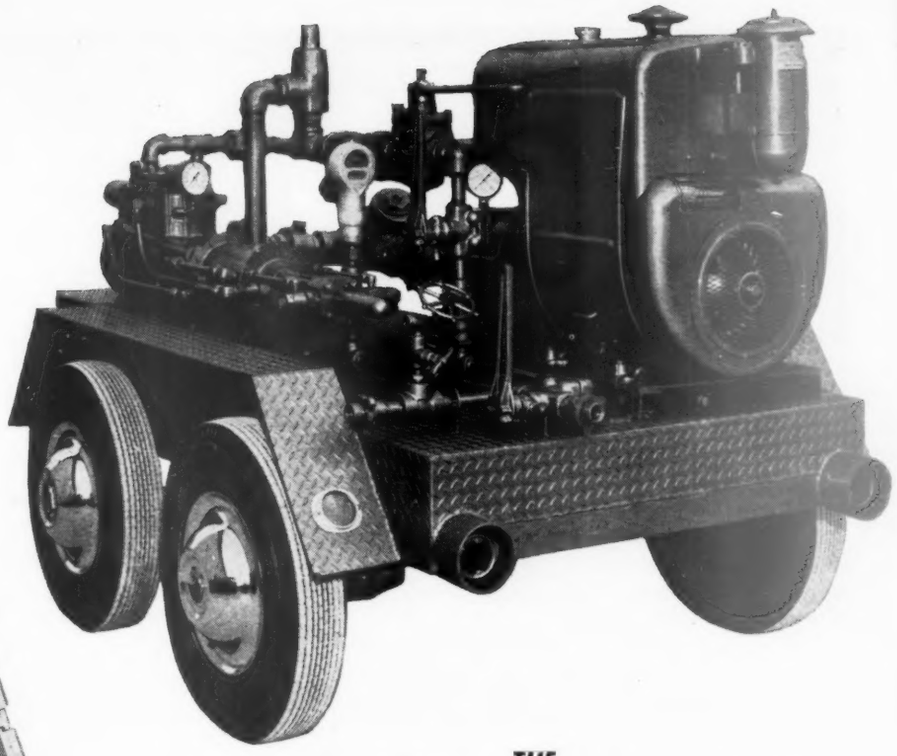

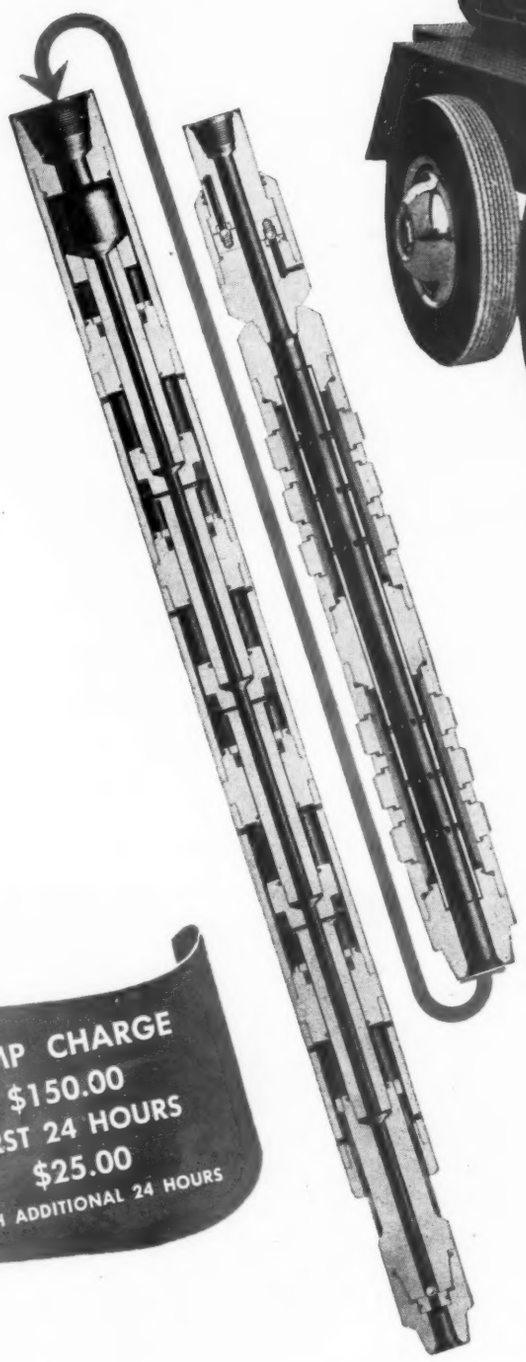

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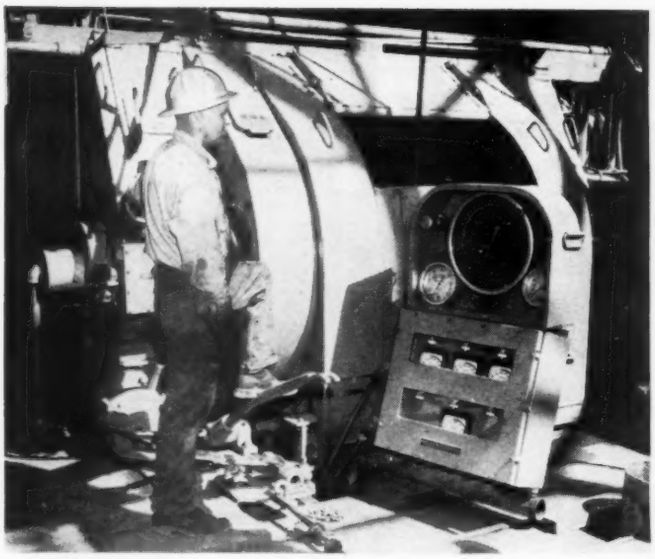
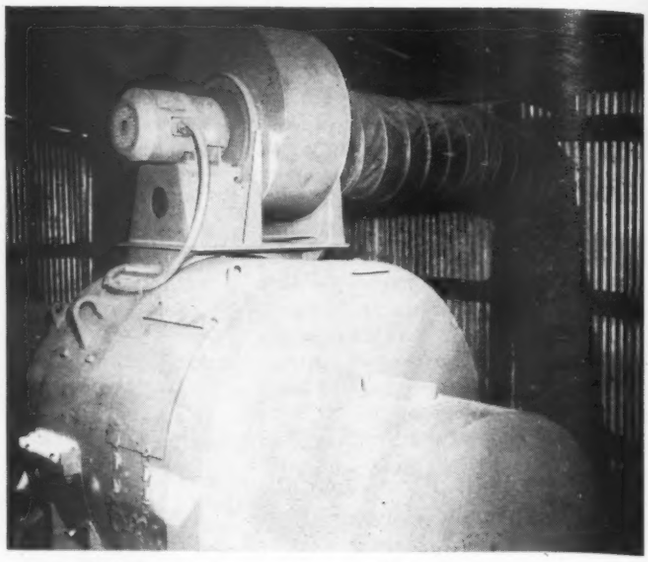


GEORGE HAMLET, driller, stands at drawworks brake.



AIR INTAKE and fan motor mounting on 800-hp drilling motor.

All-Electric Drilling Rig Makes Debut

Development of a completely electrical drilling rig is consummated in this unit designed for work in Ventura

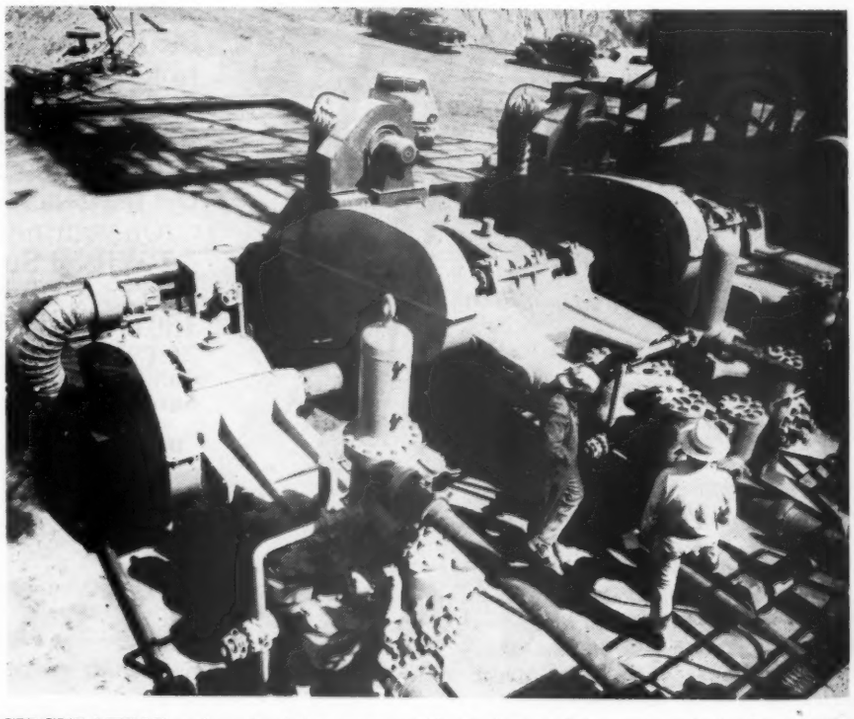
RICHARD SNEDDON*

As the culmination of a long period of planning, Tide Water Associated Oil Company recently introduced in the Ventura Avenue field in Ventura, California, the first all-electric drilling rig to be used on the West Coast and perhaps in the world. Most of the so-called electric rigs designed and built up to the present time have been of the combination diesel-electric type but the Tide Water outfit is about as completely electrical as it is possible to make one and it is undoubtedly a real innovation in the rotary drilling field.

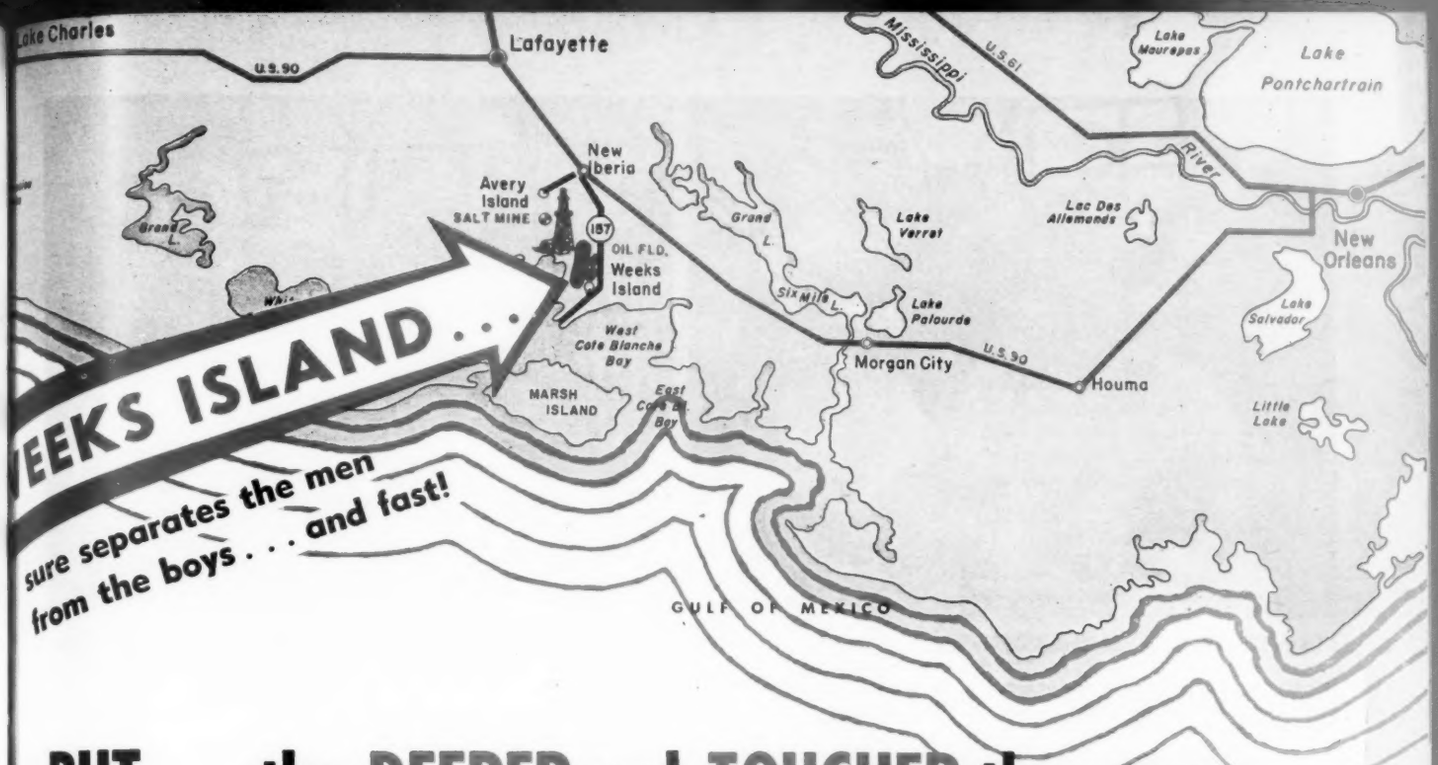
This ultra modern, variable voltage rig derives its power from ac-dc motor generator sets, which include the main power generators, auxiliary power units, and an additional small generator to hold the voltage. By a fortunate circumstance, Tide Water Associated at the time it began operations in Ventura Avenue had brought into the area a 16,500-v, three-phase, 60 cycle power line, and this, of course, had a considerable influence on the planning for the all-electric rig. It almost seems, indeed, as if the power line installation many years ago was made with this very development in mind.

The main components of the new

*Pacific Coast Editor.



CIRCULATING and mud mixing pumps with air duct and fan motors in background.



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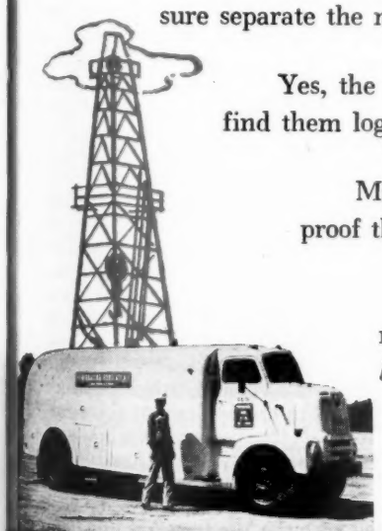

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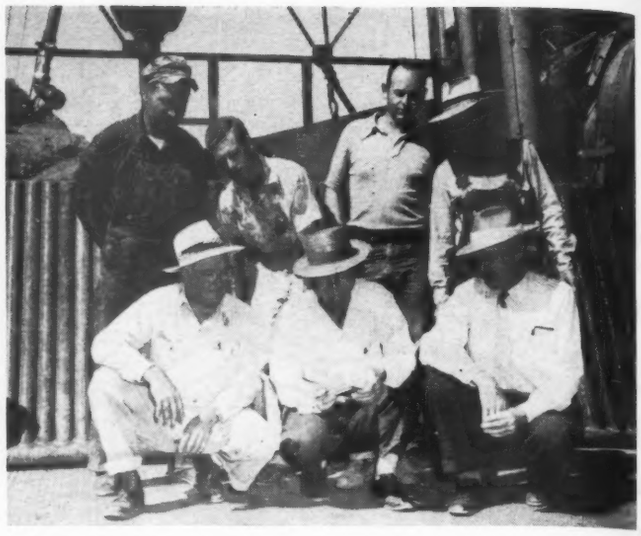
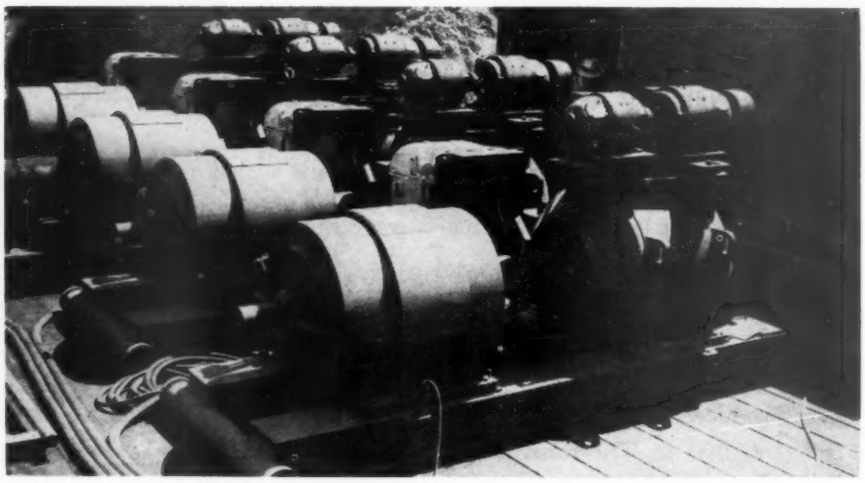
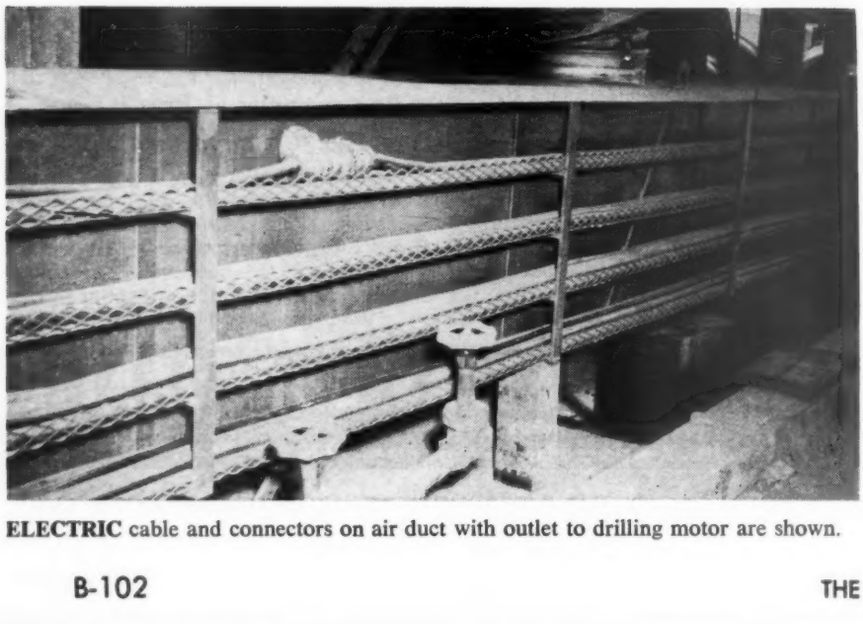
FRONT ROW: L. A. Deford, tool pusher; A. P. Isenor, assistant drilling superintendent; M. Mears, drilling superintendent. Back row: H. O. Berry, rotary helper; J. B. Watts, rotary helper; Gene Kuntzman, tool dresser; Jack Gilifillan, derrick man; George Hamlet, driller.



FRONT ROW: L. A. Deford, tool pusher; A. P. Isenor, assistant drilling superintendent; M. Mears, drilling superintendent. Back row: H. Reed, welder; N. Nichols, Westinghouse service engineer; A. Kinney, electrician's helper; C. Goss, electrician.



FOUR AC-DC motor-generator sets, each consisting of following: (1) 380 hp, type CS induction motor, 1200 rpm, 2300 v, 3 phase, 60 cycles; (2) 250 kw dc variable voltage main generators, 1200 rpm, 395 v; (3) 10 kw, 125 v constant voltage auxiliary generators to be mounted on top of 250 kw generators and belted thereto, and (4) variable voltage exciters, mounted on top of 250 kw generators and coupled to auxiliary generators [item (3) above]. Control panel is in background.



ELECTRIC cable and connectors on air duct with outlet to drilling motor are shown.

rig are, first, three 500 kva, single-phase transformers, which reduce the incoming 16,500 v to 2300 for outdoor service. These are oil insulated, self-cooled, and are mounted on a six-wheel trailer for placement wherever they may be most convenient to the power source. Then there are the four ac-dc motor generator sets, already mentioned, consisting each of the following:

a) One 380 hp, type CS, 1200 rpm, 2300 v induction motor.

b) One 250 kw, dc, variable voltage, 1200 rpm, 395 v, main generator.

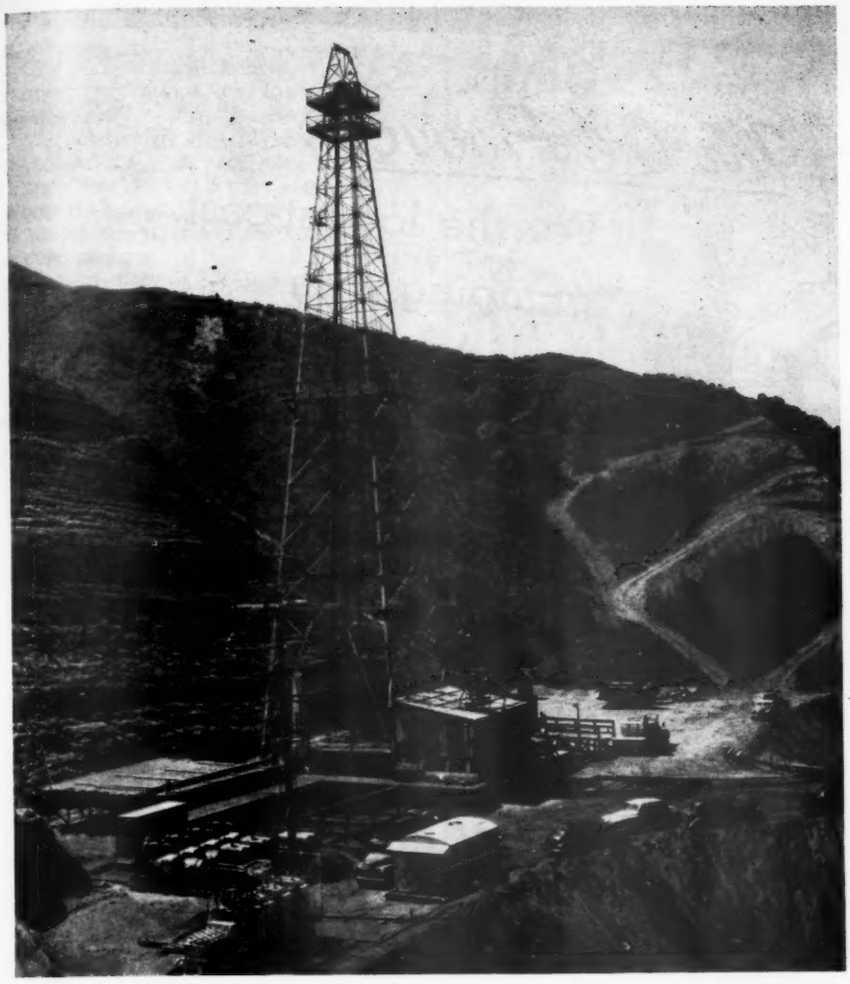
c) One 10 kw, 125 v, constant voltage, auxiliary generator, mounted on top of the 250 kw unit and belted thereto.

d) One variable voltage exciter, also mounted on top of the 250 kw unit and coupled to the auxiliary generator.

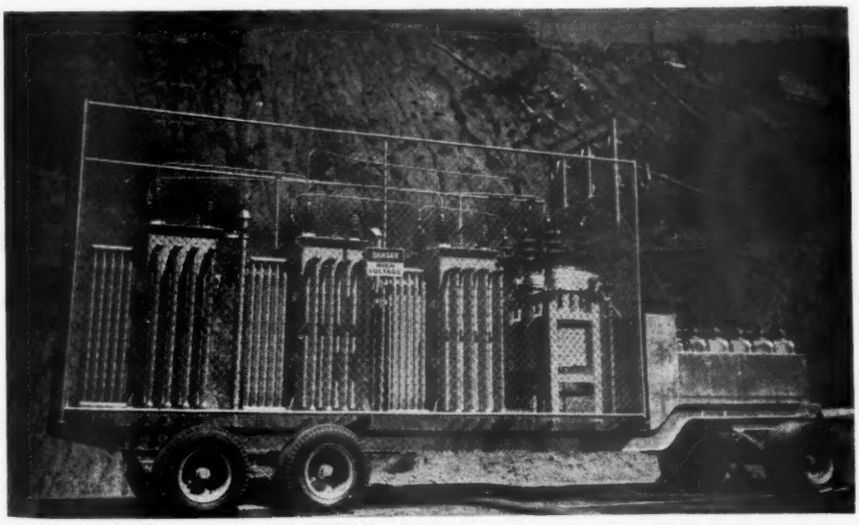
In order to permit the continuance of operations during failure of the electric power, two motor generator sets are equipped with gas engines.

Other major items are an 800 hp, 395 v, 600 rpm, dc, two-bearing, force ventilated motor for a 34 × 10½ drawworks. (This motor is capable of developing 1340 hp without overheating.) Two 500-hp, 395 v, 900 rpm, dc, force ventilated main mud pump motors, each driving one pump. An air duct, mounted in the dolly walk and unloading rack, for cooling all the motors. Air is forced thrrough the duct by a 33-in. fan to supplement the cooling effect of the motor blowers and each motor has a tributary flexible air tube from the main duct.

The entire assembly was pretty well schemed with the Ventura Avenue field in view. Here, because of the remoteness of most drilling locations, the cost of deep drilling operations is a very substantial item. In addition, the terrain in this area is rugged and personnel skilled in the operation and maintenance of any kind of deep drilling equipment are scarce. The development



GENERAL view of rig site V. L. and W. No. 104.



THREE 500 KVA, single phase, transformers 16,500 primary volts and 2300 secondary volts for outdoor service, oil insulated self cooled, mounted on 6-wheel trailer.

program thus demanded the utmost in simplicity so that operation might be continued uninterruptedly as long as possible without too much mechanical complexity. Many factors, of course, led to the decision to build an all-electric rig and now that one is actually in service, its performance will be watched with great interest by drilling engineers everywhere for it has at some time or other been in the dreams of most of them.

The need for safety as well as simplicity, and as a rule they are complementary, was also given ample consideration in the control mechanism and in all other parts of the total entity. Provision is made, for example,

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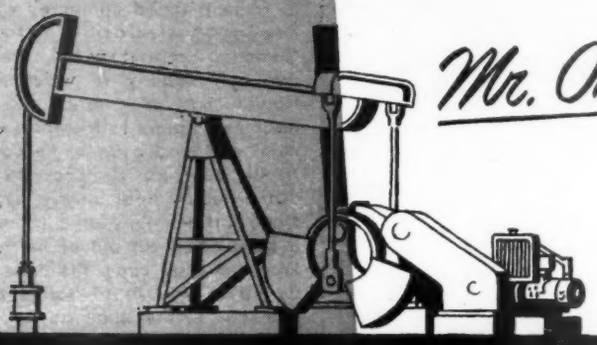

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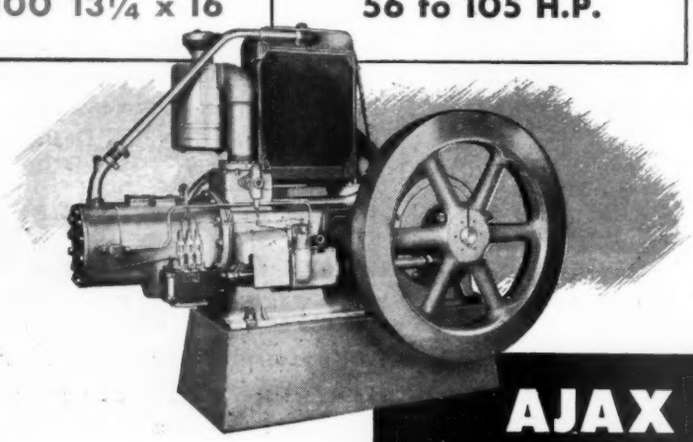

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for automatic switching of the main power voltage should one of the doors of the compartment housing the contactors and relays be inadvertently opened.

The all-electric rig was designed to reduce as far as is consistent with effectual operation the time required to get the bit back on the bottom, in other words to speed round trips and ultimately leave more time to the fundamental business of making hole. This, of course, if it can be done, means lower daily operating costs as compared with the use of so-called mechanical rigs. The whole project should provide the answer to many unanswered questions and even if in the preliminary stages of usage a few bugs should intrude themselves, it is merely a matter of time until electric drilling finds its place in the diverse processes of oil exploitation.

Transmission of energy by electric wiring makes it possible to place the control cabinet and generators in the most convenient spots in relation to other equipment items, and the electrical units are relatively small and light so that the transportation problem is a minor one. The heaviest pieces in the whole set-up are the drawworks and the mud pumps, and there is an overall compactness that promises a distinct possibility of some saving in rig moving time. In drilling operations as in most businesses, time is money, and the whole structure has been designed to perform its function with the minimum expenditure of manual labor and the minimum sacrifice of time.

. The dc motor speed is governed by a rheostat controlling generator excitation, so that should the driller run into trouble in the hole, he can adjust the motor rpm accordingly. A motor ammeter is installed directly below the weight indicator and in consequence the driller is apprised at all times as to what power load he is carrying. Also, a variable gear ratio permits the pulling of heavier loads at lower speeds and makes available maximum torque for the drilling process.

There are three main power buses, each carrying on its operation simultaneously and yet independently, and each capable of separate and adequate control. It is possible, for example, at one time to be pumping at full power with one pump, rotating the table, and working a second pump as a mud mixer, Higher flexibility in the distribution of power is attained by the use of control switches so that if at any time one or more generator sets should be out of service, the available power can be applied to the most important job to be done at the moment, whether it be hoisting, pumping, or rotating.

The engineers responsible for the development of the all-electric rig concede that its initial cost is slightly higher than would be the cost of a mechanical rig of equivalent power. On the other hand, they contend that the ultimate life of the electric rig will be considerably longer and that in the deeper drilling projects it will definitely pay off. * * *

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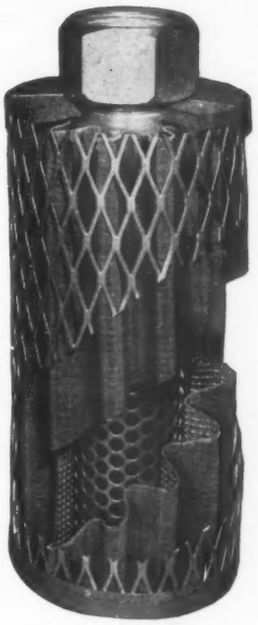

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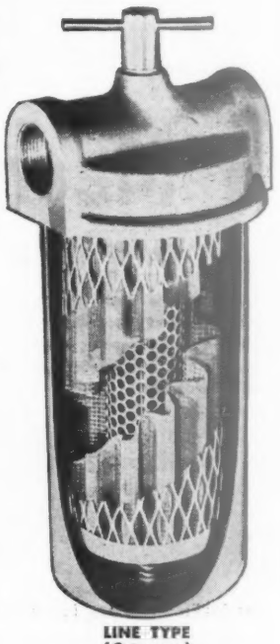
Because of the combined, outstanding features, in both construction and performance, Marvel Synclinal Filters bring about the greatest degree of efficiency in all production equipment where filtration of liquids is of the utmost importance.



LINE TYPE (Cutaway)
For installation on Crank Case, Lube Oil Filtration, Pump Line Pumping Engines, Gas Compressors, Reciprocating Compressors (single or combination), Engines—Well Pumping or Drilling, and Hydraulic Powered Construction Equipment.

LESS MAINTENANCE

Because Marvel Synclinal Filters may be disassembled, cleaned and reassembled in a matter of minutes by any workman, filter maintenance "downtime" is reduced to the absolute minimum. Line types operate in any position and may be serviced without disturbing pipe connections.

A SIZE FOR EVERY NEED

Marvel Filters are available in sump and line types, in capacities from 5 to 100 g.p.m. and in monel mesh sizes from 30 to 200. Depend on Marvel Synclinal Filters for all your filtration requirements.

TEST AND INSPECT — BEFORE YOU BUY!

To qualified engineers and operators in oil companies and contracting firms we will send a MARVEL SYNCLINAL FILTER to test and inspect before purchase. Please advise type (sump or line), G.P.M. and mesh size you desire for this purpose.

WATER FILTERS In response to the great demand, we have adapted both our sump and line models for use in all water filtering applications. No changes have been made in the basic synclinal design.

MARVEL
ENGINEERING COMPANY
625 West Jackson Boulevard
Chicago 6, Illinois
Phone—Franklin 2-4431

Marvel Engineering Company, PET-2
625 W. Jackson Blvd., Chicago 6, Ill.

Without obligation, please send me complete data on Marvel Synclinal Filters as follows:
Catalog No. 106 for Oil Filters
Catalog No. 300 for Water Filters

Name_____
Company_____
Address_____
City_____ State_____

Which

SHAFFER CELLAR CONTROL GATE

best meets YOUR requirements ?

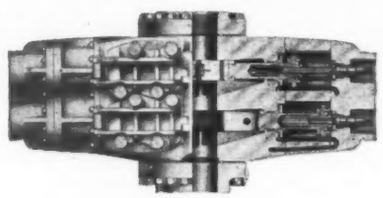
Shaffer—And Only Shaffer—gives you this important selection in pressure control equipment . . . a choice of either Hydraulic or Mechanical operation, plus a choice of either Double (two gate compartments unitized into one compact body) or Single type in both designs!

Still another advantage—if your operations are such that you use both Hydraulic and Mechanical Cellar Control Gates in your field operations, there is no need to stock duplicate rams and rubbers. In Shaffer Gates, rams and rubbers are interchangeable, size for size, between hydraulically-operated and mechanically-operated equipment. This means further savings in inventories, greater simplicity in maintenance.

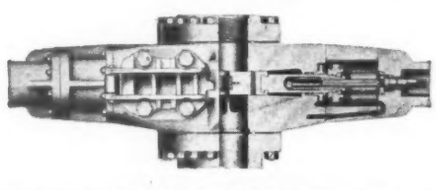
Hydraulic

OPERATION

In these Gates, rams are opened and closed by hydraulic fluid under pressure. Their operating speed, convenience and quick adaptability to various hook-ups make Shaffer Hydraulic Gates ideal for a wide range of modern drilling applications.



The Shaffer Hydraulic Double Cellar Control Gates provide two individually-operated ram compartments unitized into one compact body. Even in sizes as large as 13⅜" (12" Series 900), only 30" overall height is required.



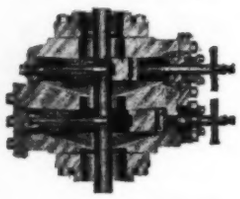
The Shaffer Hydraulic Single Cellar Control Gates may be used singly, or with other Single or Double Hydraulic Gates, to provide one or more ram compartments to meet various operating requirements. This gate requires only 18½" overall height in sizes as large as 13⅜" (12" Series 900).

Both Double and Single Hydraulic Gates provide:—Unmatched simplicity in changing rams by merely opening doors in the gate body . . . completely enclosed design with no exposed moving parts . . . self-draining compartment bottoms . . . direct hydraulic drive without yokes or secondary connections . . . and many other exclusive advantages.

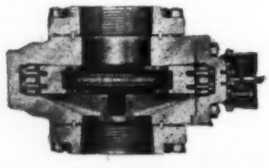
Mechanical

OPERATION

In these Gates rams are opened and closed by synchronized operating screws rotated by a compact motor drive—or manually. Simple and compact, Shaffer Mechanical Gates are very easy to install and are preferred by many operators for certain types of operations.



The Shaffer Mechanical Double Cellar Control Gates provide two separate ram compartments unitized into one compact body. Even sizes as large as 13⅜" (12" Series 900) these Gates require only 28½" overall height.



The Shaffer Mechanical Single Cellar Control Gates may be used singly or with other Single or Double Mechanical Gates to provide one or more ram compartments, as required. Need only 17⅜" overall height even in sizes as large as 13⅜" (12" Series 900).

In both Double and Single Mechanical Gates, rams can be changed by removing only one end cover . . . compartment bottoms are self-draining . . . well pressure is used to assist the sealing operation . . . and there are many other advantages.

See the Shaffer section of your Composite Catalog.

Write for your free copy of the Shaffer Catalog.

For full details on the many far-reaching advantages built into Shaffer Cellar Control Gates—and other Shaffer products—see your nearest Shaffer representative. Or write direct!

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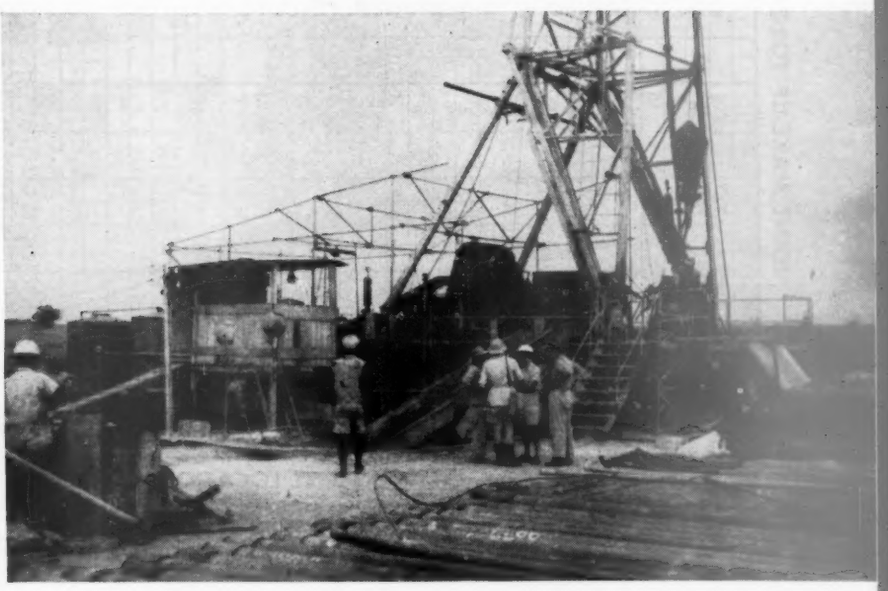
31 YEARS OF OIL TOOL LEADERSHIP

XUM



Two views of Purfina's Santiago No. 1 in Angola.

First Test Drilling in Angola

CARLOS A. ALVES PEREIRA

IN 1952 The Companhia dos Betuminosos de Angola carried on its prospecting of asphalt-bearing deposits in the Caxito area for road surfacing, and also its research and survey of bituminous deposits.

The Companhia dos Asfaltos de Angola also carried on its exploitation of asphalt-bearing mineral deposits in the Libongos area, using the material for road surfacing.

The Companhia de Combustiveis do Lobito "Purfina" (Carbonang) requested from the Portuguese Government, a concession in Angola for the prospecting of solid, liquid and gaseous hydrocarbons more specifically petroleum, naphtha, ozocerite, natural gas, as well as sulfur, helium, etc.

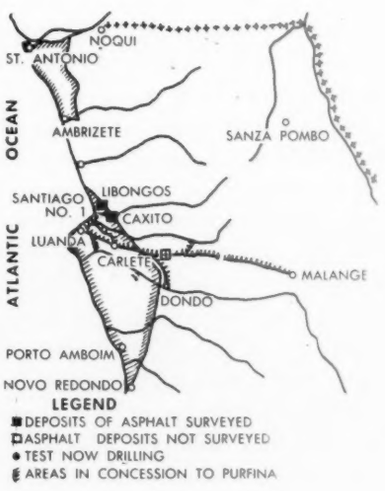
By decree July 18, 1952, the Government authorized the Ministry of Overseas Affairs, to enter into a contract with Purfina. This decree defined the area of the concession and basic conditions of the contract.

Purfina was authorized to start preliminary work early in 1952. It begun field work in June and did the following in the last half of 1952 and 1953:

Surface geology	**18 months**
Gravimetry	**4 months**
Seismography	**7 months**

Various favorable strata were located for testing. An area of 45 km to the Northwest of Luanda was picked out by surface geology confirmed through seismographic survey. Santiago No. 1 was spudded in December 6, 1952, and reached a depth of 7940 ft December 31, 1953. * * *

The Purfina test is close to coast north of Luanda.



Portion of Angola showing oil concession of Purfina.

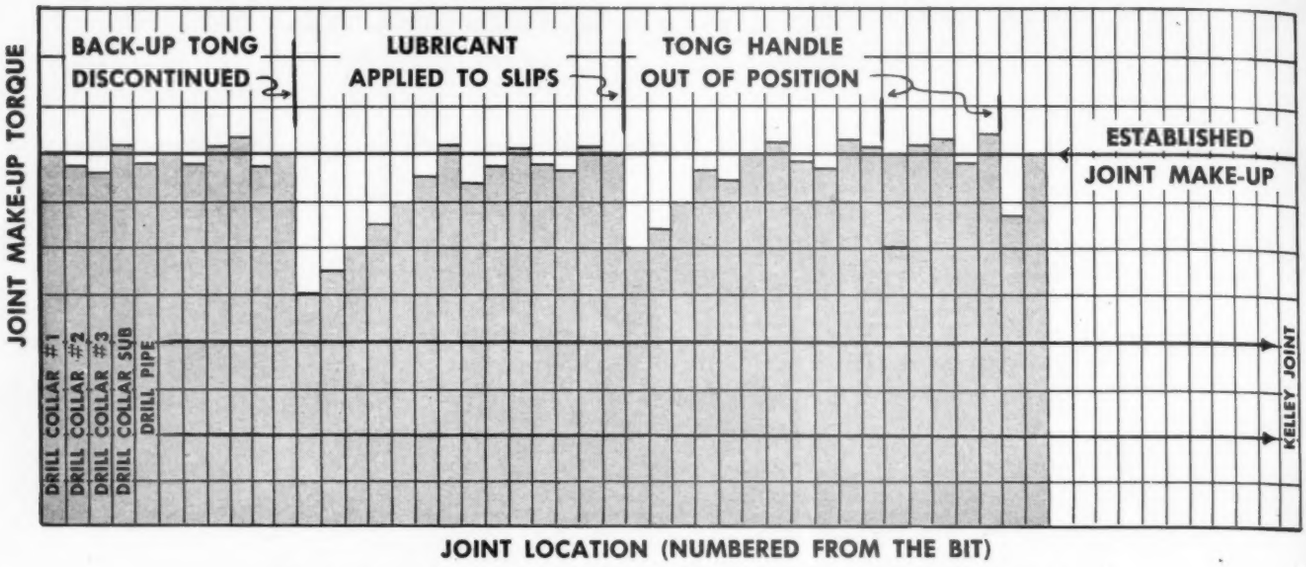


FIG. I. diagram showing typical variation in joint tightening which can occur when making up a drilling string by conventional methods.

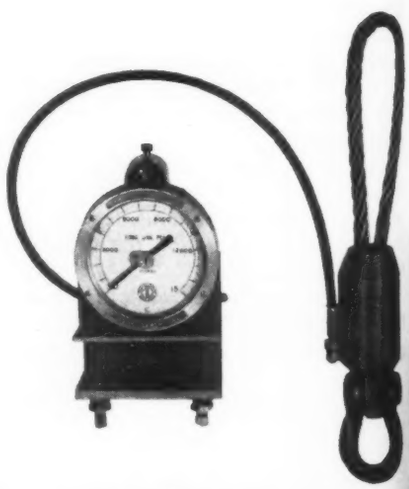
New Tool Reveals Unsuspected Causes of Loose Tool Joints, Drill Collars and Drill Pipes

Fig. 1 Above illustrates graphically three conditions which can result in undertightened joints unsuspected by the driller. These joints then become likely points for a washout to originate. The tool which visually shows these conditions on the rig is the Martin-Decker Tong Torque Gauge, which many progressive operators are now using as insurance against these troubles.

The sharp drop-off in joint torque at the point where use of back up tongs is discontinued is apparent when a Torque Gauge is used and the back up tongs are removed at the point where it appears that the slips are holding. The drop-off is due to a combination of two things. The slips turn slightly in the bowl and do not give as solid a back up as the tongs, thus the momentum effect of the cathead clutch is lost by this cushioning. Also, in turning in the bowl, the slips allow the tong handle to turn past the operating position—which is normal to the jerk line. This has the effect of shortening the effective lever arm of the tong handle. Utilization of the torque gauge will show the driller at what joint the back up tong may be safely discontinued. In many cases this will prove to be farther down the hole than the joint where it appears that the slips are holding against rotation.

The second condition illustrated by the graph shows the effect of lubricating the slips. The result is a decrease in joint torque if lubricant is applied shortly after removal of the back up tongs. If lubricant is applied while the back up tongs are in use, the result is a longer interval before the tongs may be safely removed. The actual effect can vary considerably depending on the type and amount of lubricant used.

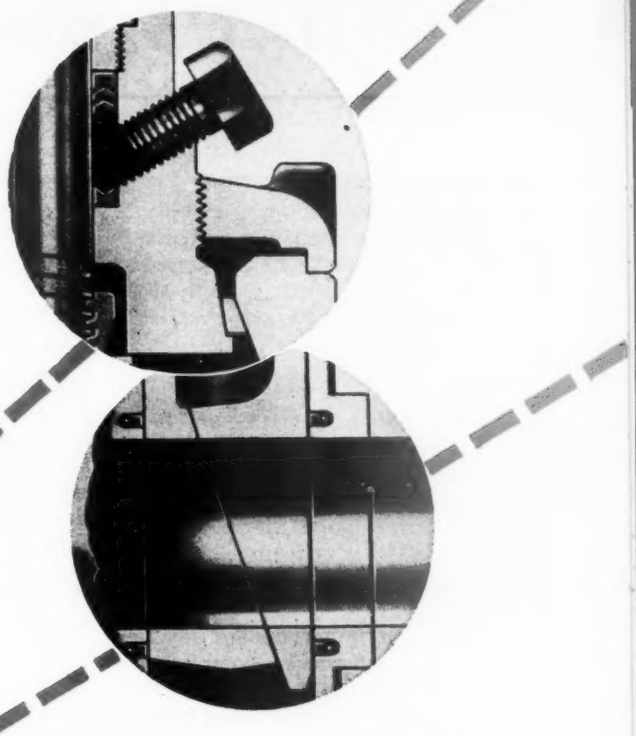
The last condition shown on the graph could occur at any point, but illustrates the effect of the tong handle being rotated out of position normal to the jerk line. The effect will not be shown by the torque gauge unless it is applied to the back up tong line. When used on the back up line, the length should be adjusted to give a right angle with the tong handle. (Advertisement)

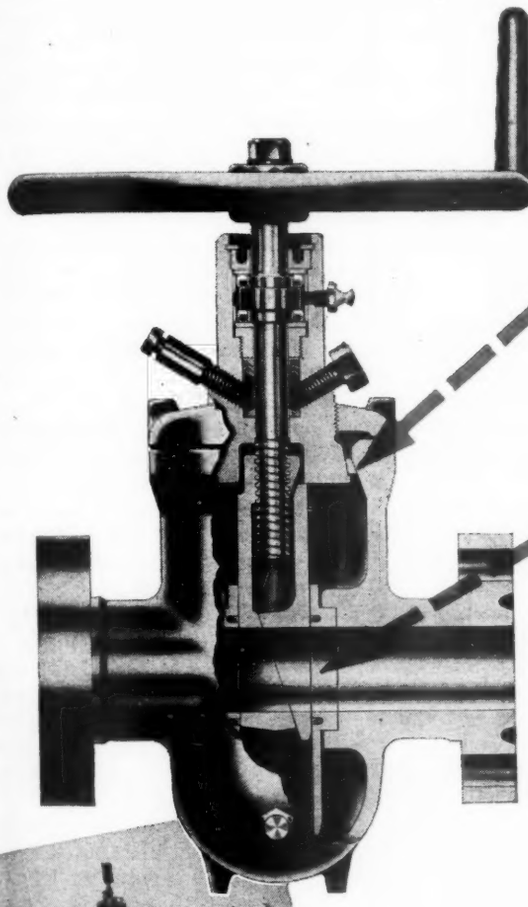


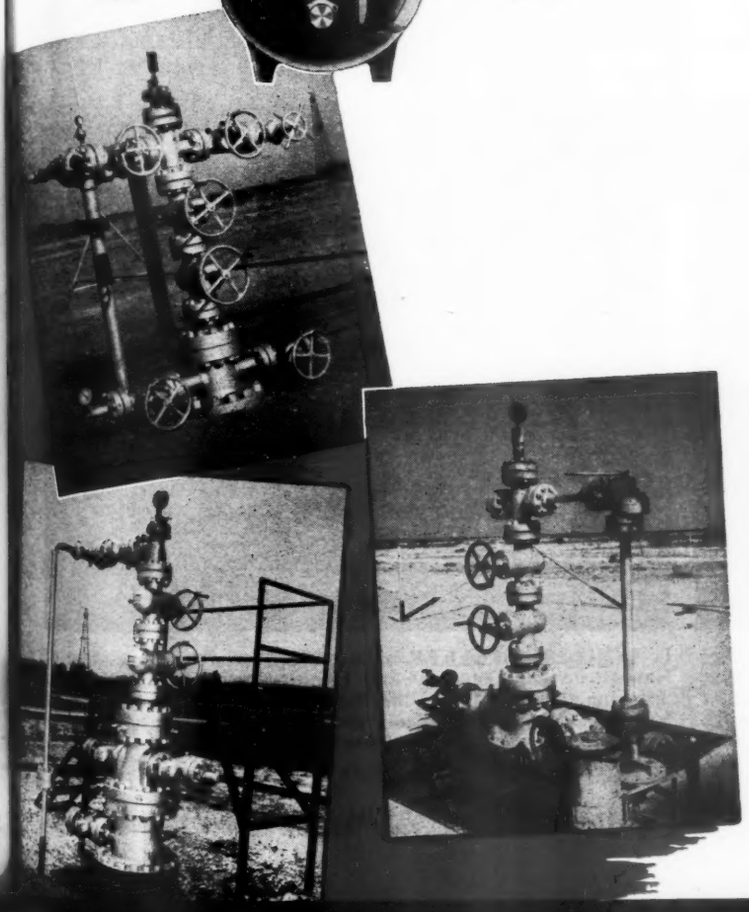
Martin-Decker tong torque gauge

Gauge installed on tongs

METAL-TO-METAL SEAL IN W-K-M VALVES INSURES COMPLETE SAFETY UNDER ALL CONDITIONS







Under high temperatures or during a fire, W-K-M Valves hold tight whether they are in open or closed position. Metal-to-metal seals at the critical points insure complete safety under all conditions. There are no "O"-rings, synthetic gaskets or inserts of any kind to burn out and cause leakage.

Even if the plastic packing should burn completely out, you still have a leak-proof closure or leak-proof conduit because the line pressure cannot enter the valve body when the valve is in open or closed position.

Full through-conduit flow without turbulence, pressure seal bonnet and superfinished roller bearing stems for easy operation are a few of the other operational advantages of W-K-M Valves which have made them standard equipment for Christmas trees the world over.

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W-K-M Valves

Eighty Percent of the World's High Pressure Wells are Controlled with W-K-M Valves

WHAT'S DOING IN DRILLING

MICHIGAN

★ The recent completion of a well in the Traverse lime formation in Washnetaw County has been announced. Producing from 1030 to 1120 ft, the W. C. Taggart No. 3 Curtis was tested at 40 bbl per hour.

CALIFORNIA

★ Confirmation test of General Exploration Company's Miocene sand discovery near Bandini in the Los Angeles area appeared headed for success. The No. 2 well topped the pay zone with some 150 ft of structural gain apparent and had good saturation through the section.

★ An extension of the Timber Canyon field was seen in the recent completion by Richfield of its No. 1 Loel-Maxwell, Ventura County. Drilled to a total depth of 9028, the well was plugged back and a string of casing set to 8560. From the Pliocene sand section encountered between 7856 and 8560, the well flowed 300 bbl of 37 deg crude per day while testing on a 22/64-in. choke.

★ A new oil well, Hartman No. 37, has been completed by Tide Water Associated Oil Company in the Ventura Avenue field, at Ventura, California. Initially flowing 981 bbl of 33.7 gravity oil through a 14/64-in. bean in 24 hours, the well is producing from a depth of 12,395 ft in the D-8 zone.

★ A new oil well, Davis No. 45, has been completed by Tide Water in the Zaca field near Los Olivos, in Santa Barbara County, California.

This well, Tide Water's 41st in the field, initially flowed 899 bbl of heavy gravity crude oil, approximately 14 deg through a ½ in. bean per 24 hours from a depth of 4542 ft in the Chert.

NEBRASKA

★ The Kiespert No. 1-A Long in the Long field of Kimball County, Nebraska, has an indicated new zone after testing the "D" sand in the interval 6138 to 6158. A 70 min test of the zone yielded 1770 ft of oil.

WYOMING

★ In Fremont County, Wyoming, in the Beaver Creek field, Stanolind Oil and Gas Company has completed the No. 30-M Beaver Creek Unit for a new well and a new pay zone discovery. The well was drilled to a total depth of 11,447 ft and was in the Madison Lime at that point. After a drill stem test of the zone that yielded good oil at an estimated 100 bbl per hour rate, pipe was set and the well completed. On potential test through a 11/64-in. choke, well was gaged at 516 bbl of 40 deg crude per day. Gas oil ratio was 130 to 1.

COLORADO

★ Lion Oil completed its fifth well in the new Adena pool of Morgan County. The well, with a total depth of 5750 ft, is the Crone No. 1 which flowed 55 bbl of oil per hour on a ¾-in. choke from the J sand.

UTAH

★ Three States Natural Gas Company has completed its No. 1 C. K. Steiner "A" for 110,000,000 cu ft of gas per day making it the largest gas producer in Utah. Absolute open flow rating of the two and one-third mile south extension well was made by engineers from El Paso Natural Gas Company. This well increases total gas reserves for the proved part of the Clear Creek field to over one trillion cubic feet.

OKLAHOMA

★ Pure Oil Company has completed an extension well to the East Noble field of Cleveland County. The confirmation well is the No. 1 Umpleby, which was tested at a 60 bbl an hour rate. Production was from the Tulip Creek sand from 7925 ft and test was made on a 32/64-in. choke. Field was discovered by Pure in August, 1953.

★ Phillips Petroleum Company No. 2 Baker "B" has been plugged back from a total depth of 8210 ft and dually completed. From the Sims sand, 5058 to 5084, and the Markham zone, 6253 to 6280, test was for 390 bbl of oil per day flowing on a 26/64-in. choke.

★ Cities Service has linked the Erin Springs and the Northeast Purdy pools of the Springer Trend of Garvin County, Oklahoma, in completion of its Showalter No. 1 stepout for a total of 416 bbl of oil daily.

Completion was based on an initial potential of 245 bbl of oil daily from the Springer and 171 from the Hart.

AAODC RECEIVES special recognition for its safety program from E. C. McFadden, chairman, industrial section of National Safety Council. Receiving award are: H. W. Davidson, recent chairman of the AAODC Safety Committee, and Brad Mills, executive vice president, in recognition of the Association's outstanding safety program.

L. A. NOMAD SPEAKER is Russell E. Havenstrite, president of Havenstrite Oil Company and Honorary member of Nomads. Speaking at the December meeting of the Los Angeles chapter of Nomads, Havenstrite is being greeted by Jim Hughes of Lane-Wells, chapter president, as Joe Schlarb of Chiksan, program chairman, looks on.

TOP quality-control here...

You can be sure of quality when you specify Unaflo Oil-Well Cement. Expert technicians regularly make many tests of Unaflo throughout its manufacture and also in our research laboratories over a wide range of simulated well-bottom pressures and temperatures. Such tests are just one phase of a continuous program of Unaflo quality-control and research to maintain and improve its performance.

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FOR YOUR CONVENIENCE, we have compiled average test results for Unaflo's thickening time and compressive strength. For your copy of this up-to-date, authoritative data, write any Unaflo office. Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Ave., New York 17, N. Y.

All tests are made according to the latest API Recommended Practice for testing Oil-Well Cements.

"UNAFLO" is the registered trade mark of the retarded oil-well cement manufactured by Universal Atlas Cement Company

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Resistant to Sulfate Waters
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Resistant to Sulfate Waters
Atlas High-Early Cement — Type III

PE-U-131R

UNITED STATES STEEL HOUR — Televised alternate weeks — See your newspaper for time and station.

Rotary Rigs Operating in Oil Fields of United States and Canada*

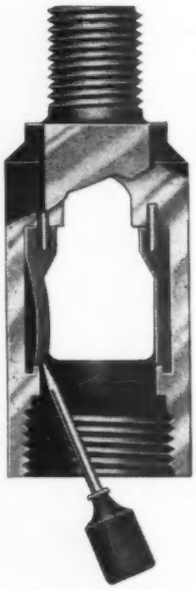
	Dec. 14	Dec. 21	Dec. 28	Jan. 4	Jan. 11
Pacific Coast	175	171	170	169	166
Oklahoma	409	413	362	353	357
Kansas	173	170	128	137	135
Rocky Mountains	298	299	271	281	272
Canada	159	150	163	144	153
Ark-La-Tex	210	199	199	173	167
West Texas and New Mexico	490	472	429	441	434
Gulf Coast	607	624	605	589	552
Illinois	170	164	138	125	126
North Texas	388	373	330	323	298
	3079	3035	2795	2735	2660

*As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

RUBBER GUIDE CAGES

John N. Martin Patent No. 2,591,174

OPEN TYPE TOP CAGE



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LOUISIANA

★ The Atlantic Refining Company has established a new oil pay in the East Baton Rouge field in the Parish of the same name. Its No. 2 Morgan is listed as the confirmation well to the No. 1 discovery. Producing from a perforated completion in the interval 9932 to 50 with a flowing tubing pressure of 1725 lb, the well was gaged at 195 bbl per day through a ⅛-in. choke.

★ In the Pecan Lake area of Cameron Parish, the Pan American Production Company has completed its 1-A Miller Unit for a gas completion in a one mile extension of the field. Casing perforations from 12,454 to 61 yielded gas at a rate in excess of 1,000,000 ft per day with 30 bbl of 48.5 deg distillate through a ¼-in. choke.

TEXAS

★ Revival of Spraberry interest may stem from the completion of the International Oil Company et al No. 5-43 Boyd, extending Reagan County Spraberry production one quarter southwest. After fracture treatment with 9000 gal, the well was potentialed at 1005 bbl per day, gas-oil ratio 1380 to 1, 40.6 deg oil.

★ The Gulf Oil Corporation has extended the Sueise field of Runnels County with the Fry sand zone completion of its No. 5 Hudson. The well was tested at 380 bbl of 45 deg oil per day, no water, with a gas-oil ratio of 442 to 1. Test was through a three-quarter-inch choke from perforations 4455 to 4464 ft.

★ In Franklin County, the Tidewater Associated Oil Company has completed the No. 1 Ramey unit in the fourth pay zone established in the New Hope field. Other producing formations are the Rodessa, Pittsburg, and Travis Peak. The subject completion was in the Smackover 12,086 to 12,341. Potential was 210 bbl of distillate in 11 hours through a 15/64-in. choke.

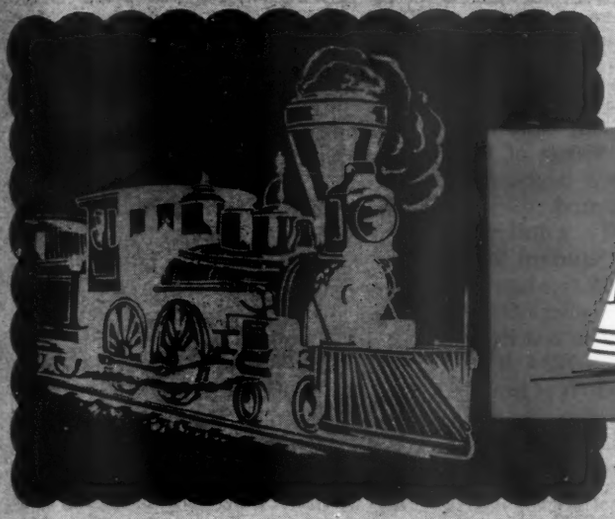
★ Cities Service et al apparently have discovered a new pay zone in the South Cowden pool of Ector County, Texas, it was indicated in a drill stem test opposite the Detrital limestone at the deep TXL K No. 1 test.

In the drill stem test between 8270 and 8298 ft, gas flowed to the surface in 27 min. A total of 6785 ft of oil was recovered, together with 215 ft of oil-and-gas-cut mud.

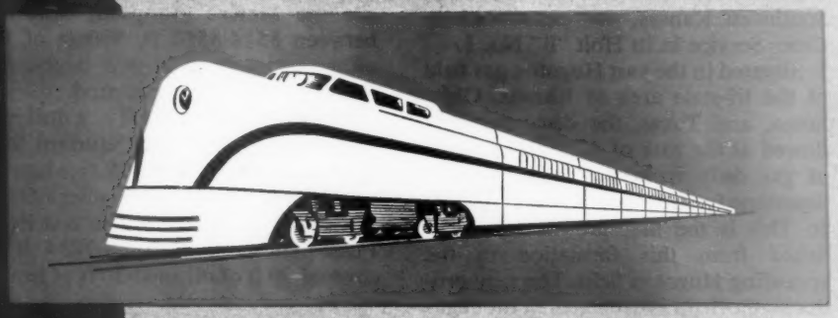
★ Sapphire Petroleums Limited, Toronto, and Kenwell Oils and Mines Ltd., Toronto, have brought in a new well in the Levelland field of Texas. It is the ninth producer on their Levelland tract of 1953 acres.

The well, F. O. Masten H-3, the Armstrong County school lands, Cochran County, produced 4½ bbl of 25 gravity oil per hour during a 36-hr test.

DON'T BUY AN OBSOLETE RIG!



A JAW CLUTCH TRANSMISSION RIG IS NOW OBSOLETE!



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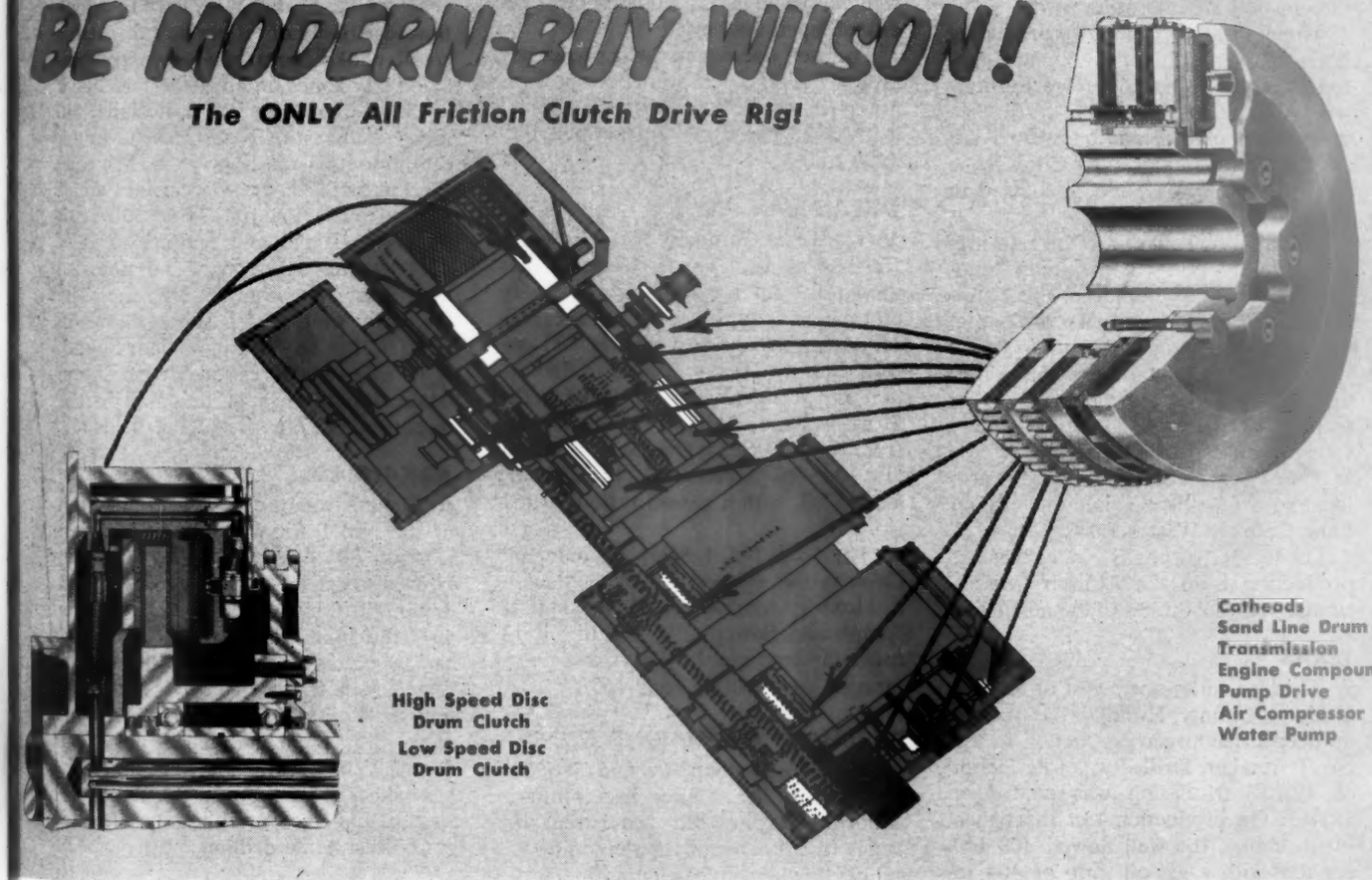
The ONLY All Friction Clutch Drive Rig!



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Low Speed Disc Drum Clutch

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Sand Line Drum
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Water Pump

There are no JAW Clutches in the compound drives, transmission or drums of a Wilson Giant, Atlas, Titan or Super Titan Rig. No cleaning, no adjustments on Air-Tube Disc Clutches . . . and you do not have to stop the drum to change speeds. Investigate these money-making features of Wilson Rigs — Today! Be Modern — Buy Wilson!

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XUM

EXPLORATION ACTIVITIES

KANSAS

★ An important gas discovery opening new reservoirs in Seward County, Southwest Kansas, was announced by Cities Service in its Holt "B" No. 1.

Situated in the vast Hugoton gas field of the tri-state area of Kansas, Oklahoma, and Texas, the discovery well flowed at the rate of 17,700,000 cu ft of gas daily from the lower Topeka limestone formation at a depth of 4200 ft. This is the first production established from this formation in the sprawling Hugoton field. The new producing horizon is deeper than the regular Hugoton gas pay, which is normally encountered at 2700 ft. Nearest production from this new zone is in the Greenwood area 45 miles away.

Three other prospective producing horizons deeper than the regular Hugoton pay will be tested before the new well is completed.

★ An Arbuckle dolomite test for Kansas has been announced by Cities Service. The test is Risse No. 1, located in Pawnee County.

Principal objectives are the Lansing-Kansas City and Mississippian limestones, the Viola dolomite, the Simpson sandstone and Arbuckle dolomite, with expected total depth of 4760 ft.

Nearest production to the Cities Service test is in the Oro pool, 4.5 miles to the east. The well is approximately four miles west of Harmony.

★ Cities Service Oil Company is also locating an Arbuckle dolomite test in Lane County, West Kansas.

The test is Murphy B No. 1. Nearest production is in the Aldrich (Mississippian) pool, 24 miles to the northeast.

TEXAS

★ Thirteen miles northwest of Rankin in Upton County, Hunt Oil has opened up deep Ellenburger production in the No. 1 Amaker. Drilled to a total depth of 12,127 ft, casing was landed at 12,013. On production test through a ¼-in. choke, the well flowed 409 bbl per day with a gas-oil ratio of 404 to 1. A prior test of the Wolfcamp in the interval 8844 to 8933 resulted in flow estimated at a rate of 40 to 50 bbl per hour.

★ In Jack County, the Wichita River Oil Company has opened a new conglomerate field at the No. 1 Sonora Coyle, two miles west of Newport. With casing set 5864 and perforated 5830 to 35, the well flowed 318 bbl of oil per day with a gas-oil ratio of 620 to 1 through a one quarter inch choke.

★ Cities Service has a second pay at the Cummins J No. 1 wildcat strike in Ector County, Texas, 24 miles northwest of Odessa.

On a two-hour drill stem test opposite the McKee (Simpson) sandstone between 8514-8550 ft, 990 ft of free oil was recovered in two hours, plus 570 ft of oil and gas cut mud.

First pay was reported in a drill stem test of the Fusselman (Silurian) limestone between 7728-7785 ft when the well flowed 94.7 bbl of high-gravity oil in two hours. A subsequent test in the Fusselman between 7788-7834 ft recovered 90 ft of oil and 930 ft of heavily oil and gas cut mud.

★ Texas Calgary Company announced the completion of its C. A. Hughes No. 1 in San Patricio County, Texas. The well was rated at 125,000,000 cu ft per day on open flow test.

The well uncovered 24 ft of net pay around 6900 ft depth. Bottom hole pressure was 3050 lb. Formation porosity was 28 per cent, and permeability 2900 md.

OKLAHOMA

★ The Texas Company No. 1 Flowers-Johnson Unit, Texas County, has shown for an apparent oil discovery that, when coupled with another excellent test across the state line in Hansford County, Texas, may give indication of a sizable field. Completed in the Morrow sand, casing was perforated from 6825 to 6855. On the subsequent test, the well flowed at 22 bbl per hour, 41 deg oil, with a gas-oil ratio of 1061 to 1.

★ The Shell No. 1 Samples, Jefferson County, has opened a new pool with a Hoxbar completion. This shallow completion flowed 294 bbl of oil in two and three quarter hours after perforating and treating zone 1638-74.

PURCHASE GEOMARINE STOCK

★ Texas Instruments Inc. and Geophysical Service Inc., Dallas, in a joint announcement disclosed acquisition by Texas Instruments of the remaining 25 per cent ownership of Geomarine Service Inc. and Geomarine Service International S. A. The purchase was a cash transaction with undisclosed terms. Seventy-five per cent interest had been acquired in April of 1953.

FLORIDA

★ A new test for the Pollard field of Escambia County has been scheduled by the Humble Oil and Refining Company. The wildcat, No. 1 Pollard Unit 8, is announced as a 6000 ft test and it is expected that zones other than the Pilot may be checked.

LOUISIANA

★ In Iberia Parish, The Shell Oil Company has received state permits for the drilling of two 15,000-ft wildcat tests. These were a part of the 41 drilling permits that were issued by the State Department of Conservation of the week ending January 16.

★ The Tidewater Associated Oil Company has completed the No. 1 O. T. Comeaux as a producer. Tested on an 11/64-in. choke while flowing from perforated interval 11,800 to 11,806 ft, gage was for 259 bbl per day with 4,460,000 cu ft of gas. This well is situated in Acadia Parish, northeast of the Northwest Branch field.

★ Phillips Petroleum Company has completed a discovery well which flowed 301 bbl of oil per day through a small choke from one of three indicated pay zones on an 8700-acre block in St. Bernard Parish, Louisiana, 40 miles southeast of New Orleans. In addition to this oil flow from Miocene sand at 5856 ft, the wildcat had a calculated open flow of 17,500,000 cu ft of gas per day from another sand at 7050 ft and also topped an untested sand above the completion zone. The discovery well, No. 1 State Lease No. 2220 in Eloi Bay of Chandeleur Sound, is 14 miles northwest of Breton Sound where Phillips has participated in the discovery of four producing fields.

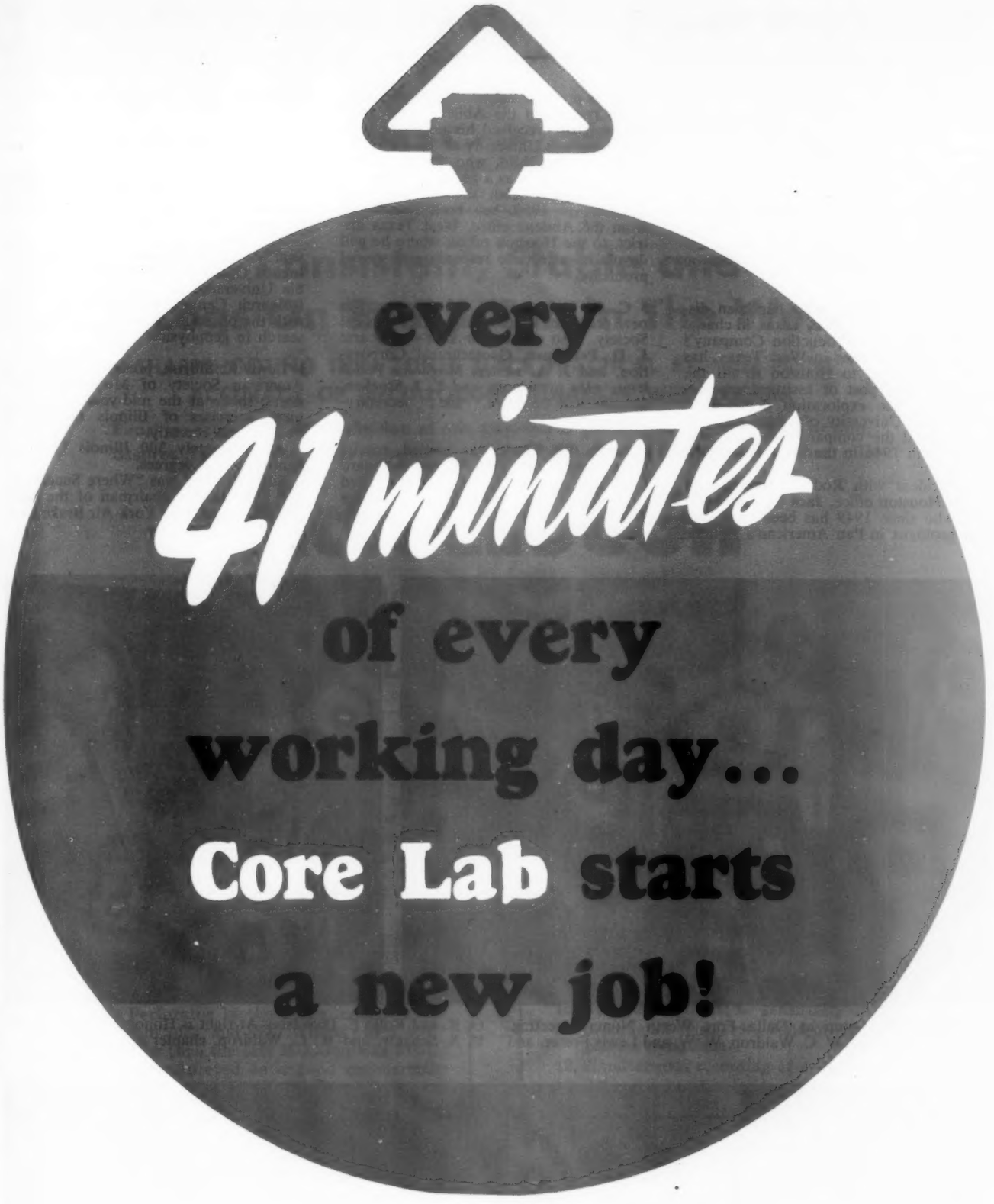
ARKANSAS

★ Sinclair announced the completion of the No. 1 John R. Nelson to open a new oil field in Miller County. Drilled to a total depth of 7313 ft, and dry in the Travis Peak, objective of the test, the hole was plugged back and casing set and perforated in the Upper Gloyd zone from 6108 to 15. In eight hours, flowing through a 24/64-in. choke the well produced 139 bbl of 43 deg oil. Gas-oil ratio was 693 to 1. This test had a good show in the Hill zone also, having recovered condensate and gas on test while drilling.

CALIFORNIA

★ Union Oil Company reported that one of its exploratory wells, Spieler 27-26, located about eight miles due east of Coalinga, Fresno County, California, is believed to have tapped a new pool.

Formation tests were made of the interval 8811 to 8870 ft, and the well flowed 36 deg gravity crude oil at a rate estimated in excess of 1000 bbl a day. This is the equivalent of the Leda zone, which is productive in the adjacent Guijarral Hills field.



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RUNNING TOUR with MEN in the INDUSTRY

▸ **T. W. G. Thomson,** manager of the Texaco Exploration Company since 1952, has been appointed vice president and manager of the company. Thomson has been a resident of Canada since 1927. He joined McColl-Frontenac Oil Company Ltd., now a Canadian subsidiary of The Texas Company, as an auditor in 1931. He joined the newly-organized Texaco Exploration in 1951. He was named acting manager that year, and manager on March 1, 1952.

▸ **William B. Rodan,** who has been district geologist at Abilene, Texas, in charge of Pan American Production Company's exploratory activities in West Texas, has been transferred to Houston to fill the newly created post of assistant superintendent of the exploration department. Rodan is a University of Texas graduate and entered the company's employ as a geologist in 1946 in the West Texas District.

Coincident with Rodan's appointment in the Houston office, **Jack H. Hendrickson,** who since 1949 has been employed as a geologist in Pan American's Abilene office, is promoted to district geologist for West Texas and the Abilene area. Hendrickson also received his degree in geology from the University of Texas.

Ray E. Fairchild, who was employed by Pan American as a geologist following his graduation from the University of Missouri in 1950, has been transferred from the Abilene office, West Texas district, to the Houston office, where he will devote his efforts to research and special problems.

▸ **C. G. Dahm,** Hunt Oil Company, is new president of the Dallas Geophysical Society. Also elected for a new year are: **J. D. Perryman,** Geotechnical Corporation, and **J. A. Lester,** Magnolia Petroleum, vice presidents, and **E. J. Stucken,** Geophysical Service, Inc., secretary-treasurer.

▸ **L. B. (Si) Clark** was named special representative of The Falcon Seaboard Drilling Company. Clark was graduated from Tulsa schools and attended George Washington University. He began his career in the industry with United Supply.

▸ **Samuel Katz,** geophysicist at Stanford Research Institute, has won the 1953 George Frederick Kunz Prize in geology and mineralogy awarded by the New York Academy of Sciences.

Announced last month in New York, the award was made for Katz' paper on "Seismic Study of Crustal Structure in Pennsylvania and New York."

The prize-winning paper reports three years of work performed at Lamont Geological Observatory (a branch of Columbia University) for Air Force Cambridge Research Center. Katz spent five years with the observatory on a program of research in geophysics.

▸ **Lewis K. Sillcox,** president-elect of the American Society of Mechanical Engineers, spoke at the mid-year commencement exercises of Illinois Institute of Technology, recently.

Approximately 300 Illinois Tech students received degrees.

Sillcox's topic was "Where Success Begins." He is vice chairman of the board of directors of New York Air Brake Company, New York City.

FATHER-SON group at Dallas-Fort Worth Nomad meeting. They are: T. C. and W. C. Waldrop, W. W. and Lewis Foster, and G. R. and Rollo E. Davidson. At right is Honorable Price Daniel, U. S. Senator, and W. C. Waldrop, chapter president.

INITIATED into the Dallas-Fort Worth Chapter of Nomads recently were: L. L. Rector, Rector Well; W. C. Watson, Daniel Orifice and Fitting; T. C. Waldrop, Oil States Rubber; Ray Gorman, Web Wilson; Price Daniel; T. E. Morton, Halliburton Oil Well Cementing; N. A. Tinker, Jr., West Texas Corporation; John Wilson, Wilson Manufacturing; E. P. Halliburton, Halliburton Company; M. F. Cribbs, Mid-Continent Supply, and W. S. Sease, Globe Oil Tools.

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NEW WAYS OF DOING THINGS

Latest News About New Tools, Techniques and Services

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with SCINTILLOMETER (GAMMA RAY AND NEUTRON LOGS)

HERE'S A GOOD EXAMPLE:

The well completed was in an old field where the zones are very thin and many of the sands produce 100% water. An error of a very few feet in measurements means the difference between success or failure. Ran the McCullough Radiation Well Logger with Scintillometer and simultaneously recorded a collar log. Collar locations checked within 6" at 3600'.

Shot four ½" burrless holes in five feet of shale for W. S. O. On bailing test, there was no fluid rise in 19 hours. Proceeded with production perforating of 200 plus holes with a 4¼" McCullough M-3 Burrless Bullet Perforator in the zones indicated by the log between 3633' and 3770'. There was a 400' fluid rise by the time the last M-3 Gun was fired. The well was completed as a good commercial producer.

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6. Extremely stable equipment.
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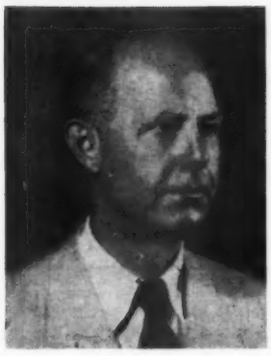
Running Tour



Lewis G. Weeks

Jarvis Garst

M. M. Fidlar

▸ **Lewis G. Weeks,** with 34 years of experience in petroleum geology in many parts of the world, has been appointed chief geologist of Standard Oil Company (New Jersey). Until his new assignment, Weeks, well known lecturer and author of scientific papers on geology, has been the company's senior research geologist in the producing coordination department. As chief geologist he will continue as a member of the exploration division, managed by G. Moses Knebel.

Weeks began his geology career in Mexican copper mining shortly after graduation from the University of Wisconsin. In 1924 he joined the Jersey Standard organization in South America, before becoming chief geologist of Standard Oil of Argentina in 1933. Later he was president of Standard Oil of Bolivia.

▸ **Jarvis Garst** has joined Housh Drilling Company and other Housh enterprises as geologist. Garst is a graduate of the University of Texas. He was employed by Continental Oil in Mexico for several years and then went with Plymouth Oil in South Texas as district geologist.

During the last five years he has been in Jackson, Mississippi, as division geologist for Honolulu Oil Corporation.

▸ **M. M. Fidlar,** Mountain Fuel Supply Company's manager of exploration, has been named vice president in charge of exploration. Fidlar's new appointment creates a new MFS vice presidency. Fidlar received his PhD in geology at Indiana University in 1942. He was assistant state geologist and state gas supervisor for the Indiana State department of Conservation, 1936-38. He was Indiana district geologist for The Ohio Oil Company for the next five years.

Fidlar went to Rock Springs in 1943 as Mountain Fuel's senior geologist. He became the company's chief geologist in 1945, and manager of exploration in 1951.

▸ **R. F. Rood** has been appointed division landman of the northeast division, Phillips Petroleum Company, which includes districts headquartered at Ardmore and Oklahoma City, Oklahoma, Wichita, Kansas, and Evansville, Indiana. He succeeds **J. S. Williams** who will handle special work, reporting directly to **C. O. Stark,** vice president in charge of the company's land and geological department. **R. N. Richey** replaces Rood as division landman for the San Juan division, which embraces the extensive San Juan Basin of New Mexico and Colorado.

P. Carver

P. W. Jackson

C. P. Bristol

▸ **Paul Carver** has been named manager of the land department of General Petroleum Corporation.

Carver succeeds B. A. Otis, who has retired after 28 years with General Petroleum. **Parke W. Jackson** succeeds Carver in the post of assistant manager of the land department.

Carver joined General Petroleum in 1938. He became a lease representative in 1945. He has served as assistant manager since April, 1953. Jackson has been with the company since 1919. He spent 20 years in engineering work, joining the land department in 1948.

▸ **C. P. Bristol,** Shell Oil Company area manager at Tulsa, Oklahoma, has been appointed vice president in charge of the company's Tulsa exploration and production area. Bristol received a degree in petroleum engineering.

He began full time employment with Shell in 1931 as a field engineer in East Texas and subsequently advanced. In 1944 Bristol became division manager in the East Texas area and three years later was appointed chief exploitation engineer at Houston. He became production manager at Houston in 1950, and was appointed area manager at Tulsa last August.

▸ **I. K. Nichols** was appointed division geologist for the southern division, Tennessee Production Company, at Houston. **J. S. Collins** was appointed division geologist for the northern division at Wichita Falls. **Jess Roach** was named district geologist of the Midland district. **C. J. Hinshaw,** district geologist, Wichita Falls district, and **William Vrana,** district geologist of the Corpus Christi district.

▸ **H. F. Dangberg** has been named assistant production department manager, Hancock Oil Company. Beginning as senior petroleum engineer for the company in 1945, Dangberg has worked in various positions of the department.

▸ **Gene L. Scheirman,** Shell Oil, has been named to head the East Texas section of the American Institute of Mining and Metallurgical Engineers. Other officers include: **Herb Miller,** Amerada Petroleum, vice chairman, and **T. A. Banta,** Lufkin Foundry, secretary-treasurer. New directors are: **John G. Calvert,** Humble; **W. T. Crowder,** Lufkin Foundry and Machine, and **M. L. Reed,** Shell Oil.

▸ **L. P. Foote,** formerly superintendent of the Markham, Texas, gas plant, has been promoted to senior petroleum engineer with headquarters in The Ohio Oil Company general office, Findlay, Ohio.

An engineering graduate of New Mexico A & M College, Foote has been associated with Ohio Oil since 1935.

▸ **John L. Ferguson,** Tulsa geologist, has announced he is entering the consulting field, specializing in exploration problems. He is resigning as vice president of Deep Rock Oil Corporation. Ferguson joined Deep Rock over three years ago to set up an organization for Deep Rock to carry on greatly expanded exploratory activities.

▸ **S. A. Berthiaume** and **J. H. Rambin, Jr.,** have been promoted to assistant general managers, producing department of The Texas Company. Both men will be in the general manager's offices, Houston.

G. T. Briggs, assistant division manager, Louisiana division, producing department, will succeed Rambin as division manager.

George A. Gammill, division land and leaseman, Louisiana division, will advance to assistant division manager. He will be replaced by **T. O. Winn,** landman on the general manager's staff.

▸ **John E. Swearingen** has been elected vice president in charge of production of Standard Oil Company (Indiana). Swearingen joined Standard in 1939 as a chemical engineer in its Whiting, Indiana, research laboratories.

After holding several positions in Standard's research department, he was transferred in 1947 to the manufacturing department of Stanolind. He became assistant to the vice president in charge of operations in 1949 and a year later manager of the company's central division. In 1951 he was made assistant to the executive vice president and elected a director.

He was graduated from the University of South Carolina.

▸ **John A. Newman** has announced opening of consultant offices in petroleum and natural gas engineering at 319 Gulf Building, Houston, Texas. A graduate of Cornell University, Newman joined Atlantic Refining, immediately after graduation in 1944. Two years later he became associated with Shell Oil, and held various positions in the Houston area.

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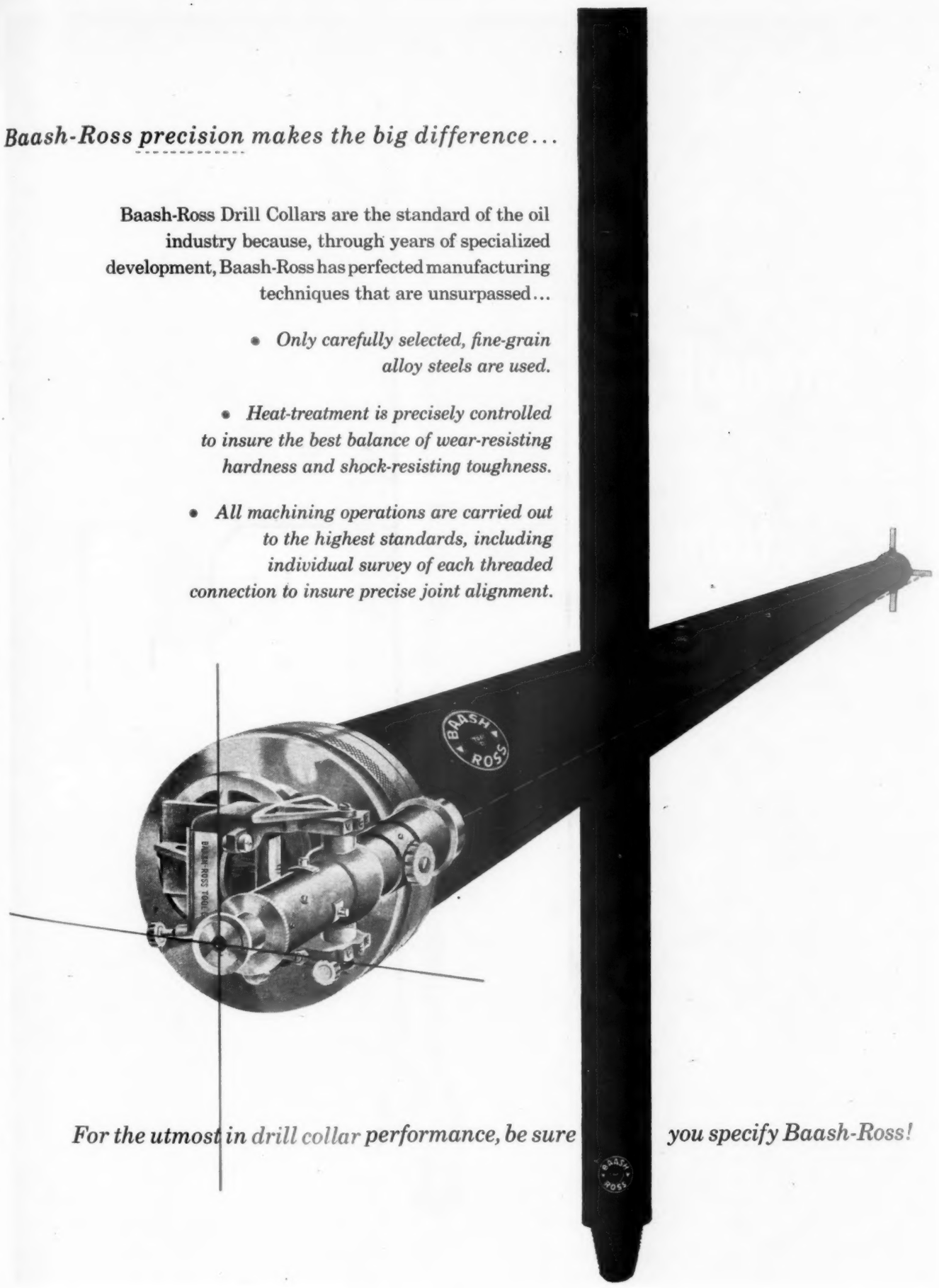

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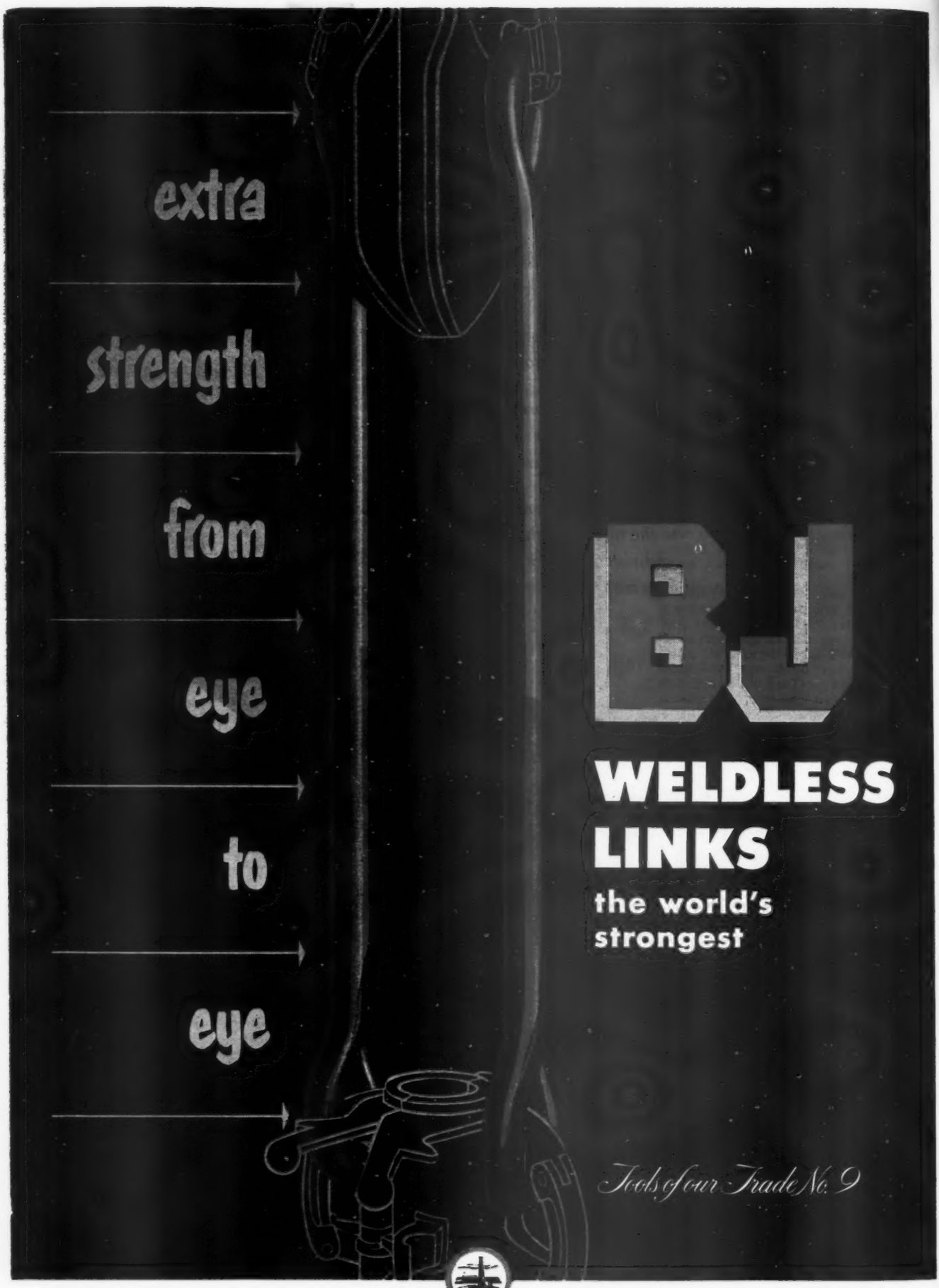

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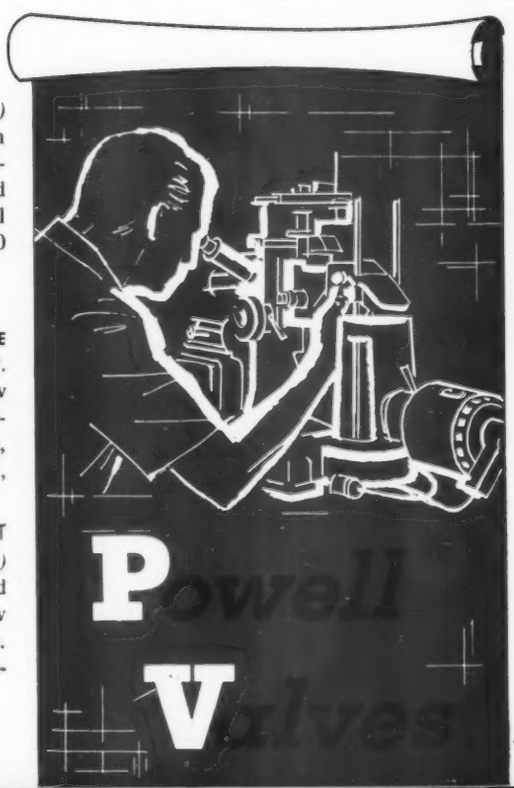
LEFT

BRONZE "WHITE STAR" GATE VALVE *(Fig. 375)* For 200 pounds W.S.P. Union bonnet with inside screw rising stem. Renewable "Powellium" Nickel-Bronze wedge. Sizes, ¼" to ¾", Solid Wedge; 1" to 3", Double Wedge.

RIGHT

CAST STEEL GATE VALVE *(Fig. 1503)* 150 pounds. Flanged ends, bolted flanged bonnet with outside screw rising stem and yoke. Solid wedge. Available in sizes 1" to 24", inclusive.



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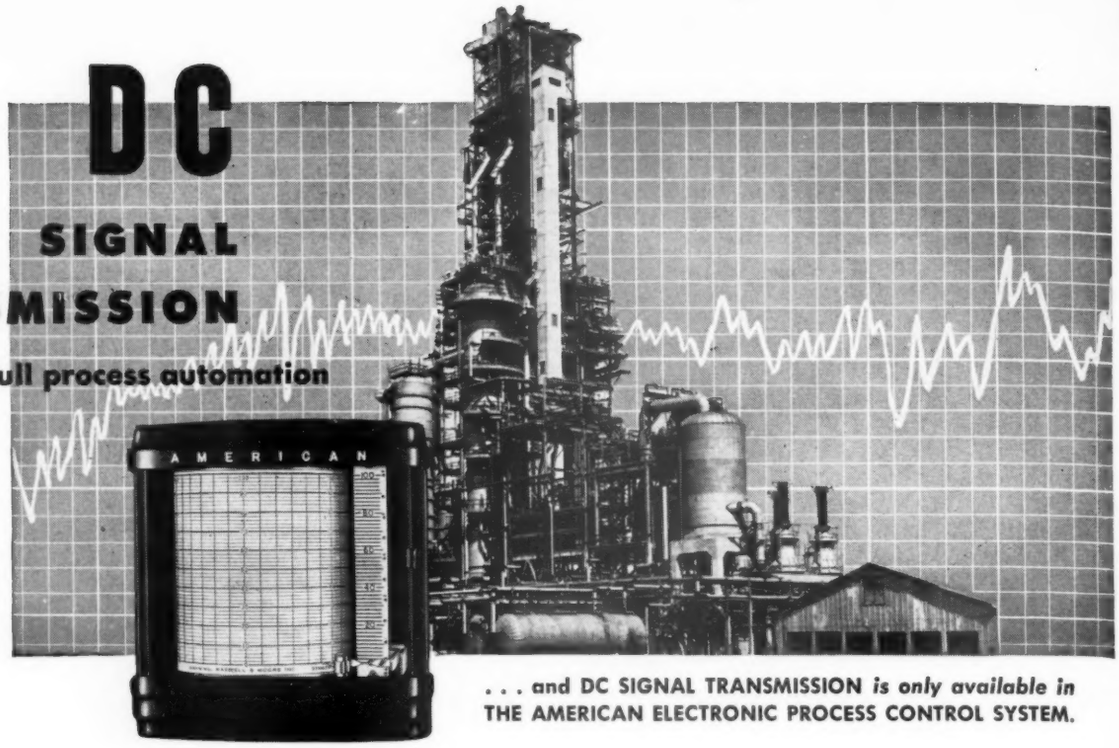

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Additives—Good or Bad?

"'Tis *so!*" — "'Tain't, neither!"

Such may be the irreducible minimum of words to describe the differences of opinion on the "raging" question of whether or not additives, in this case tricresyl phosphate, are or are not good when used in motor fuels for automotive engines.

In two papers given before the Society of Automotive Engineers in Mid-January, two well known and reputable research organizations differed widely in the conclusions they draw from experimental work in combatting spark plug fouling and preignition in automotive engines. Giving these outfits the designation of A (Shell Oil) and B (Standard Oil Development), some of their differings are indicated by these statements:

"A:" "There is currently a definite spark plug fouling problem."

"B:" "Preignition and spark plug fouling do not appear to be pressing problems in current engines."

"A:" "* * * * Reported that tests on 30 cars in normal service showed that 95 per cent gave preignition on commercial fuels."

"B:" Preignition is a limiting factor in determining car octane requirements in less than 7 per cent of all cars."

"A:" "TCP is effective in eliminating or minimizing both spark plug fouling and preignition."

"B:" "Cars operating on the fuel containing tricresyl phosphate (TCP) gave: a. Less wild ping; b. higher detonation requirements; c. greater power loss; d. poorer fuel economy; e. no advantage in spark plug life."

In statements from others it came out that valves are damaged "after 8000 miles" of operation with TCP.

Conclusions may not be drawn safely from these brief and scattered quotations, unless these data are associated with the context in each case. But the discussion certainly goes far to prove the correctness of the conclusion given by "B" group that "The importance of the problem caused by combustion chamber deposits certainly justifies work to develop satisfactory additives to combat these problems."

★ ★ ★

Wanted — More Engineers

Industry needs more engineers than the colleges are turning out, says the ECPD, (Engineers' Council for Professional Development) and that body means to "do something about it."

A training program was instituted last year at Cincinnati for nearly 300 students and plans are to do the same thing in five other locations this year. Efforts are to be made, including circulation of a new booklet "Engineering — A Creative Profession," to high school students, along with counsel to every high school in the U. S. and Canada to induce students to take up engineering. Present practicing engineers in the middle and lower brackets fear this may bring in so many new engineers that salaries will be "revised downward," but the Council points the heavy demand for engineers and the present prospects for industrial expansion as indicating that some such course must be followed to supply industry with the required number of trained engineering personnel.

★ ★ ★

Ethylene Oxide

A new process of making ethylene oxide by air oxidation of ethylene bids fair to reduce costs of this important petrochemical. It eliminates chlorine as indirect oxidation agent and gives very high yields. One plant operating in France (Naphtachimie, Lavera, France), designed by process developers, Scientific Design, Inc., has already exceeded design capacity of 17MM lb per year. New plant being designed "for a major chemical company" in Texas. Like the refining industry has been for years, process advances are obsoleting commercially operating processes before the equipment wears out, or old plant can be amortized.

★ ★ ★

Italian Refinery Operating

The new Condor refinery at Rho, near Milan, Italy, has just completed its trial run and is on stream, with a rated capacity of 1,800,000 tons (12,500,000 bbl) per year. Stone and Webster Engineering was process and basic design engineers, E. B. Badger and Sons, Ltd., of London, S. and W. subsidiary, management and construction heads of the project.

★ ★ ★

Sioux Buys Refinery

The Cooperative Refinery at Newcastle, Wyoming, has been bought by Sioux Oil Company, says its president, C. F. Harshfield. This boosts Sioux's total refining capacity to 500 bbl of crude per day.

Chemical Pipe Lines Next?

For more than a generation the petroleum industry has used tankers to move large amounts of crude and refined products. Now the chemical, including petrochemical industry, goes one better and converts or builds tankers for liquid chemicals. Two or three petroleum tankers have been rebuilt for this purpose; now comes Bethlehem (Steel) Shipyards and builds outright an 11-compartment tankship Marine Transport Lines, (NYC) who charters it before launching to Dow Chemical to carry organics, and inorganics from Freeport, Texas, to East Coast delivery centers.

Special materials are used in compartments; rubber lining for hydrochloric acid; nickel-clad steel for caustic soda, with nickel valves, piping, pumps. No chemicals touch the vessel's shell, the annular space may be in water ballast or in Grade A petroleum product transport. Segregated piping, venting and arrangements are used, to prevent contamination of products. New chemical ship is nearly 200 yards long, 37½-ft deep, 23,440 tons, carries 118,000 bbl liquids, 7700 shaft horsepower. Now, we're getting somewhere!

★ ★ ★

Electrolytic Regeneration

Three plants for the electrolytic regeneration of wash caustic have begun operation recently, under the American Development Corporation (ADC) process, J. H. Salmon president, announces. These plants are at Sun Oil, Sarnia, Ontario; Leonard Refineries, Inc., Alma, Michigan, and Raffineries Francaises de Petrole, de L'Atlantique, Donges, France.

★ ★ ★

Limit Oil Shale Work

Argument against extension of Synthetic Fuels Act is gaining momentum. Interior Secretary McKay said work at Rifle, Colorado, will be discontinued on large-scale refining of shale oil, pointing out that original concept of Bureau of Mines' policy was to drop research and development work as soon as they reach competitive status in private industry. Bill was proposed in 1948 for $350,000,000 loan to build synthetic fuel plants. Under this Act, some $87,000,000 has been appropriated since 1944 for research. The B of M appropriation in fiscal 1954, which ends June 30, was only $4,500,000.

More Platinum Catalyst

American Cyanamid plans to build a $1,500,000 platinum catalyst plant at Willow Island, West Virginia, according to a Certificate of Necessity issued to the company that granted quick tax amortization for part of the sum at 65 per cent, about 16 per cent of it at 50 per cent write-off. The catalyst will be sold for "petroleum refining," that is, assumedly, catalytic reforming of light hydrocarbon fractions.

★ ★ ★

Ethylene From Oil Gas Yet

Did Semet-Solvay, branch of the Allied Chemical and Dye tree, "pull a fast one" when it designed and built (via Lummus) an ethylene and polyethylene plant where the olefin is obtained from fuel oil instead of from light (natural gas or refinery "waste" gas) hydrocarbons? That is what has been done at S.-S.'s new plant at Tonawanda, New York, periphery of Buffalo. That company follows the chemical industry's open-mouth policy of admitting that the plant is operating as of the first of '54, then feels it has already said too much, clams up.

Twenty million pounds of polyethylene per annum is the projected goal of this plant, say officials. For combining with petroleum waxes, where narrow melting point range is advantageous; emulsion-based and paste-type polishes (shoe shines coming up!) are among the uses, and P-E gives cost and property advantages over some vegetable waxes.

★ ★ ★

Atomic "Water Boiler"!

Look at the amount of safeguarding, insulation, protection needed to boil a gallon or two of water, H_2O to the chemist, via atomic reactor heat! Standard of California's Research and Development subsidiary announces a "nuclear chain reactor" or "pile" at Livermore, California, research station for AEC. The installation — "A steel sphere, 1 ft diameter, containing a uranium sulfate solution in water, the uranium content enriched by additional isotope U^{235}—imbedded in a stack of graphite bars — set in a (cylindrical) steel tank 5 ft diameter by 5 ft high — surrounded by several inches of lead to stop radiation escape — the whole enclosed in a concrete wall 3 ft thick!"

This reactor has two cadmium control rods, to maintain the reactor at the power level wanted; two boron rods are installed, to shut off the reactor or for "emergency control." Again, if the reaction "runs away" it produces so much heat that the water boils over into a drum, stopping automatically the chain reaction. Unit operates at 100-w power, giving a billion thermal neutrons per square centimeter per second for experimental work; power can be boosted to 2000 w if wanted in future. What is a "thermal neutron?" Wish these scientists would speak U.S. English, for once.

★ ★ ★

To Get "Double O"

Stanolind Oil and Gas Company has hired The Lummus Company, well known refining and petrochemical engineers, to study and report on the physical condition of the plant of Carthage Hydrocol at Brownsville, Texas, closed recently and apparently not to be opened under its previous management. If this report is favorable,—it will require several months—it will then take several months more to put the plant into condition for operation, should Stanolind decide to buy the property.

It is remembered that Stanolind built and operated a chemical concentration plant near the Hydrocol plant, for the purpose of recovering the various alcohols, aldehydes, acids, ketones, etc., formed as byproducts of the processing at Hydrocol, where natural gas was converted to heavier hydrocarbons and these oxygenated organic chemicals. At earliest it should be well into 1954 before any decision is made on the purchase plan.

★ ★ ★

Tariffs – and Troubles

A national "set-to" over whether or not tariffs on imported chemials shall be lowered, raised, or ignored is a black cloud forming on the 1954 horizon for the Federal Tariff Commission, The Federal Congress and the chemical industry. The Manufacturing Chemists Association (MCA) and the Synthetic Organic Chemical Manufacturers Association are both marshalling forces to present their cases to the Congress to induce that body to maintain what the chemical industry considers adequate protection.

Already SOCMA, led by President C. R. Wagner, is presenting a stupendous report to the Randall Commission on foreign economic policy. The MCA led by President W. C. Foster, contends that any tariff revisions should be made on the basis of individual products or related groups of products, not "across the board" (by implication at least).

More "Cats" for Australia

Construction of a cat cracker—process unannounced—and eventually a catalytic polymerization unit is scheduled in 1954, for the Geelong (Australia) refinery, "out of Melbourne, 'crost the Bay," will add materially to the down-under Aussies' capacity for production of better motor fuels, petrochemical intermediates and similar products for home consumption. Crudes reportedly will come from Seria field, British Borneo, production, also from Middle East sources, it is said. Units include feed preparation, the cat cracker proper and cat poly. Charge capacity is stated as 650,000 tons per annum, or, at 7 bbl per ton, and annual throughput of 4,550,000 bbl which reads 15,000 bbl daily, approximately.

This sounds like more possible outlet for Iranian crudes, if and when AIOC gets that flowing out of Mossadegh's desert. With a new plant going up at Cockburn Sound, West Australia using 21,000,000 bbl, and others elswhere, that country's present outpue of only 15 per cent of its domestic petroleum products requirements will receive a decided boost.

★ ★ ★

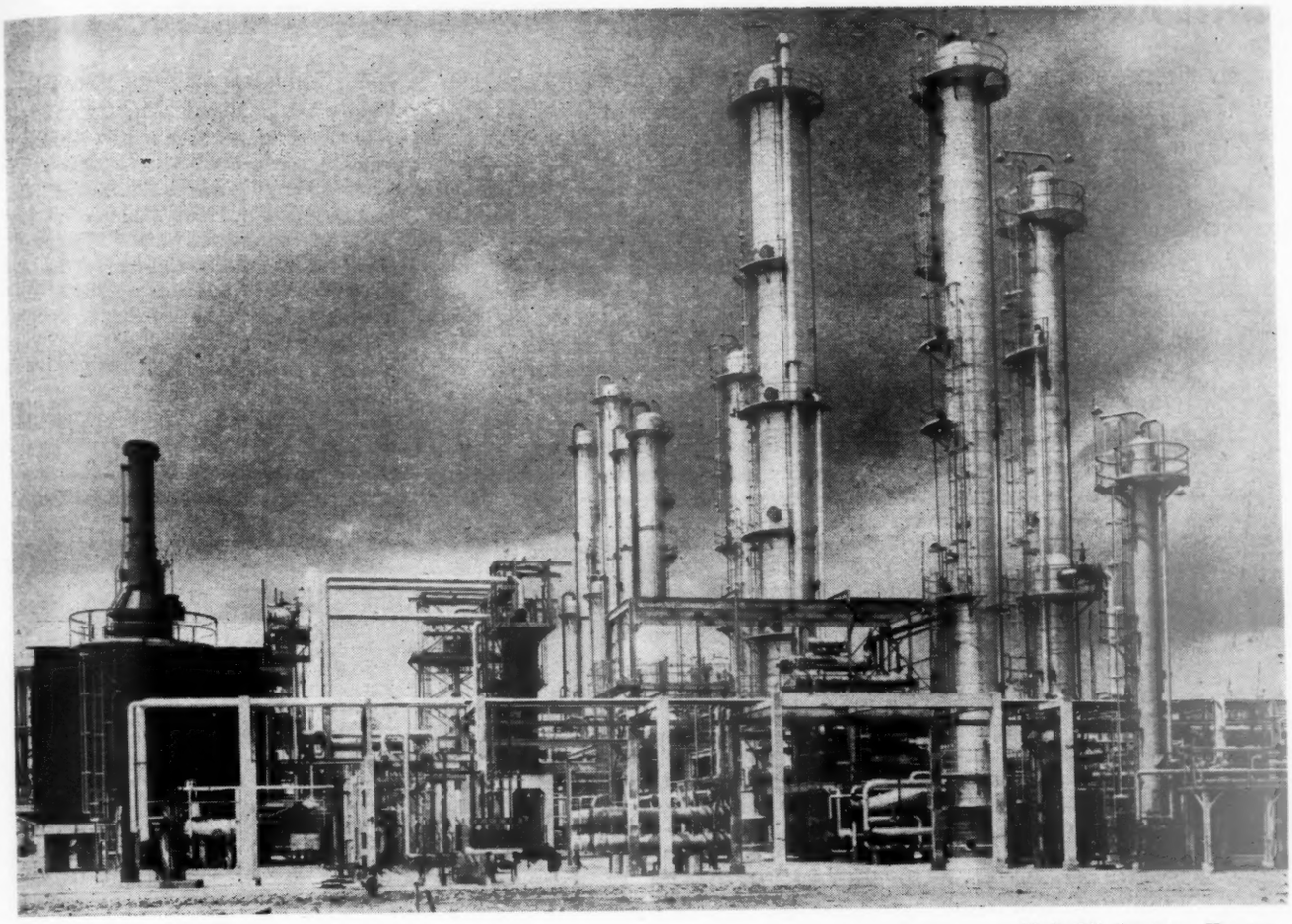
DMT Plant Underway

Dimethyl terephthalate—from paraxylene—will be synthesized in a $4,000,000 plant at Burlington, New Jersey, by Hercules, to supply British-Canadian-operated ICI Terylene plant at Millhaven, Ontario, with 12,000,000 lb per year. Plant building is beginning right away. DMT will be made by a new direct oxidation process developed recently at cost of $1,500,000 by California Research Corporation. Plant is to be operating by May, 1955, and will supply other foreign Terylene manufacturers in countries other than Canada with dimethyl terephthalate.

★ ★ ★

Dacron for M'Lord

Prospects for Dacron fiber output are upped by manufacture of paraxylene in 98 per cent or higher purity by Phillips' Big Spring, Texas, plant. Taking the raw fraction from Cosden Petroleum's refinery across the fence, the forbearer of terephthalic acid and Dacron is purified and recovered by a system of continuous fractional crystallization to separate it from ortho and metaxylene and other "impurities" present. Raw material comes from Cosden's Platformer-Udex unit, reforming low-grade naphtha.



—*Shell Oil Company, Houston.*

LARGEST PLATFORMER in commercial operation anywhere in the world has a design capacity of 16,000 bpsd for motor fuel production and 13,000 bpsd for aromatics. Catalytic processes are now essential in modern refinery operations, and petrochemical processes.

Part 2

Development of Petroleum and Petrochemical Processing

Research foundations of modern petroleum processing and chemical manufacture

BENJAMIN T. BROOKS*

RESEARCH work as a foundation for many modern processes of refining is in many cases related closely to research leading to the manufacture of chemicals from hydrocarbons. Much work along both lines has been done simultaneously, and to a large degree independently. Both draw, however, upon the ever increasing reservoir of the fundamental chemistry of hydrocarbons, and the oil and gas industries

*Chemical consultant.

This article outlines and emphasizes the fundamentally important scientific discoveries that laid the groundwork and became the foundation stones of present and future process advances that have made the oil and allied industries leaders in industrial development. The author shows the basis for research progress, the effect of fundamental researches and findings on practical, applied technology. He points out the far-reaching results of the work of Midgley, Lovell, Whitmore, Ipatieff, of Curme, Fischer and Tropsch in the effects on process development for making better automotive, aviation, and other fuels, and the complete dependence of the industry on practical experimentation based on fundamental research's findings.

The third article in this series, discussing further petrochemical advances, raw materials, etc., will appear in an early issue.

EXCLUSIVE

supply the raw materials for synthetic products.

Timing of Discoveries and New Processes

Research is the process of expanding known scientific knowledge. It is very often a race by different individuals or groups in making the next advance, which is one of the fascinations of such work. One conspicuously successful independent inventor of chemical processes, the late Carleton Ellis, was quick to perceive the trends of research and invention and, with a good imagination, foreshadowed by the research of today.

It is equally true that most inventions cannot be made or industrial processes be carried out successfully before their time, i.e. before other necessary factors are worked out or the economics of the process permit profitable operation. Two cases well illustrate this. The conversion of ethylene to ethyl alcohol and ethyl ether by sulfuric acid was simple chemistry dating back over a hundred years to the time of Michael Faraday, and in 1897 Fritzsche attempted the industrial manufacture of ethyl ether in this way,

Gomberg Chlorine-Water Reaction

It is also of interest that the chlorohydrins and corresponding glycols had long been known but the chlorine-water method used industrially since the early 1920's was a discovery by M. Gomberg[9] during World War I and directly due to the fact that until the sulfur chloride method of making mustard gas was developed by Pope and Levinstein, ethylene chlorohydrin was the only raw material known from which mustard gas could be made. Although ethylene glycol is now also

DR. GEORGE O. CURME, vice president of Chemicals Research of Union Carbide and Carbon Corp. The research foundations of Carbide's pioneering manufacture of chemicals from hydrocarbons has been under his direction.

THOMAS MIDGLEY, JR., pioneer in the study of engine knock and the discoverer of the value of tetra-ethyl lead. "More and more research of the fundamental type will be necessary," said Midgley.

DR. CECIL E. BOORD, Research Professor of Organic Chemistry, Ohio State University; since 1925 active in the synthesis of hydrocarbons, cooperating with Lovell in study of engine knock; now engaged in study of hydrocarbon oxidation.

WHEELER G. LOVELL, director of Automotive Products Research, Ethyl Corporation. "The usefulness of a hydrocarbon fuel to produce useful power in an internal combustion engine depends not upon heating value, but molecular configuration."

Some of the Men Who Pioneered in the Synthesis of Hydrocarbons and Their Utilization

acted quickly and obtained a large number of patents and was a frequent contender in patent interferences. Most research is a logical development from earlier work, which tempts some critics to characterize such advances as "me too" researches. It is seldom, however, that a discovery is what the Germans call "bahnbrechend" or highly original and opening up quite new fields. A few discoveries are more or less accidental, but Pasteur once remarked that accident benefits only the one who is prepared to understand it and act upon it.

It is this logical sequence of research which so frequently results in patent interferences, for example the four-party interference in the case of dewaxing and removing asphalt by liquid propane, and the five-party interference in alkylation by chemical reagents. Tomorrow's inventions are being particularly favored by the alcohol tax situation.[8] He made ethylene by cracking petroleum oils and removed propylene and other light olefins by their reaction, with much tar formation, with concentrated sulfuric acid. The successful production of synthetic ethyl alcohol, and ethyl ether as a by-product, came much later, 1930, after the art of cracking was well advanced, the separation of ethylene from propylene and other olefins accomplished by distillation methods and the recovery of sulfuric acid was greatly cheapened by improved methods. Similarly the first industrial attempt to make ethylene and propylene glycols from the olefins and hypochlorous acid (1917), gave a mixture of the two glycols,[3] the first industrially practical method of separating ethylene from propylene being that of Haynes and Curme (1923).[10]

made from other raw materials, the industrial importance of the many products derived from ethylene chlorohydrin, including the glycol, ethylene oxide, glycol ethers and a score of other products, enables one to say without exaggeration that the chlorine-water reaction discovered by Gomberg is the most important single reaction in the whole field of the manufacture of chemicals from hydrocarbons.

In connection with the matter of the timing of inventions and new processes it may be noted that the history of modern industries is packed with instances of the impact of new developments in one industry profoundly affecting one or more others. This is probably why bankers and those who play the stock market find it so difficult to follow the changing patterns in the industrial kaleidoscope. This is sometimes difficult even for the in-

siders, as illustrated by the fact that the director of research of a chemical company which has been outstandingly successful in producing a large number of chemicals from hydrocarbons, and finding new markets for many of them, told the writer recently that he and his research staff had never been able to predict correctly which of their new products would have the largest sales, and that a few had been "duds."

Propitious timing of new manufacturing undertakings is not altogether a matter of market statistics. Market surveys are sometimes the refuge of the timid or the ultra conservative, and have probably stifled many a potential new enterprise. The case of ethylene glycol and the series of compounds related to it indicate how misleading surveys of established markets can be. Up to the early 1920's it was known that a small amount of ethylene glycol could be used as the dinitrate with nitroglycerine in making low-freezing dynamite. There was practically no established market and this was equally true of ethylene oxide, glycol ethers and a score of other now well known related products.

In fact the company that pioneered the manufacture and sale of these products never made a product for which there was an established market for several years, until about 1930, when the business had become so profitable that the risk of manufacturing a product which had a known and competitive market was undertaken. This was ethyl alcohol, made from ethylene instead of from molasses. It should be pointed out however, that for the industrially new products the profits were high, as is usually the case in such circumstances, protection being secured by secrecy in manufacture and to some extent by patents. Probably the reason for much of the secrecy surrounding the manufacture of chemicals from nonbenzenoid hydrocarbons is due to the fact that in many cases the basic chemical reactions are simple and have long been known. Under these circumstances broad patent protection can seldom be secured and the details of the technical "know how" become all-important. This information and experience is very costly to the company who pioneers a process and there are always many others ready to follow, after the pioneer has successfully demonstrated the value of it.

Incidentally it may be noted that guesses or market surveys of probable sales of ethylene glycol and ethylene oxide, made since 1930, have often been wrong, erring on the conservative side, for the industrial uses for these substances have been multiplied by correlative research in other industries.

More often the timing of new enterprises follows events creating new demands. Thus it was originally the effort to use the surplus stocks of nitrocellulose after World War I which led to low viscosity nitrocellulose and the rapid adoption of nitrocellulose lacquers. This created large new demands for acetone, methyl ethyl ketone, methyl isobutyl ketone, butyl and amyl alcohols and their acetates, and other solvents. Another example of interest is furnished by the vinyl chloride polymers, which have been known since 1872 and were well described by Ostromislenski in 1912. Manufacture on a large scale came with the growth of the plastics industry. Thus the basic foundation of the vinyl plastics was laid many years ago but their practical adaptation as useful plastics required much further research on co-polymers having modified properties, plasticizers and mechanical treatment.

Vinyl chloride was made many years ago from ethylene dichloride by elimination of hydrogen chloride, and from acetylene by the addition of hydrogen chloride. But although these simple reactions were old, the determination of optimum reaction conditions, proper apparatus, instrumentation, purification, et cetera, required much further work, as is usual in such cases.

It was indicated above that the prompt advances from research results often led to patent interferences, but it is of interest that there is sometimes a curious and considerable time interval between the discovery of certain key facts and the first industrial applications of such discoveries. The reasons for such time lags are not always discernible, although every competent research group turns out more new things of value than the supporting company can utilize promptly.

For example it was well known during World War I that ammonia was catalytically oxidized by air, in the presence of a platinum catalyst, to oxides of nitrogen (or nitric acid). Oxides of nitrogen and methane at high temperatures yield hydrocyanic acid, and that a mixture of methane, air and ammonia gives good yields of HCN, using a platinum catalyst at high temperatures was discovered in 1930.[1] A recent patented improvement relates to the use of nearly pure methane or gas containing not over 7.5 per cent ethane. However, a full twenty years elapsed between the initial discovery and its industrial installation, even though the cost of hydrocyanic acid from cyanides remained high throughout this period. The large demand for HCN for the manufacture of acrylonitrile for synthetic textiles and GRN rubber has evidently caused the industrial use of this process, coupled with the catalytic reaction of HCN with acetylene to give acrylonitrile. The manufacture of acrylonitrile from ethylene oxide and HCN, followed by decomposition with loss of water, is not likely to survive.

Another interesting case of delay or slow research progress is that of the recently industrialized oxidation of cumene and cymene by air to the tertiary hydroperoxide and the acid catalyzed hydrolysis of the latter to phenol, or p. cresol from cymene, and acetone. Earlier workers,[16] (1940-1942) oxidized cymene by air at about 140 deg to methyl acetophenone and cumic acid. They observed the formation of the hydroperoxide but they were after the other products and evidently overlooked the much more valuable products made from the hydroperoxide. The new phenol-acetone process was industrialized by others ten years later, 1952. Methyl acetophenone, an objective of the earlier process, is now a relatively minor by-product of the new phenol-acetone process.

Research From Automotive Engine Study

Compulsion of events in profoundly affecting petroleum processing was discussed in the first article of this series in connection with the drastic changes, mostly credited to better engineering, brought about by the rapid growth of the automotive industry. The same factor was a powerful stimulus to research along many lines. One line of investigation thus stimulated was the study of engine performance and particularly the question of engine knock. This resulted in the discovery of the anti-knock value of tetraethyl lead by Thomas Midgley, Jr.,[13] and TEL remains the most effective additive for suppressing engine knock. These early investigations started a chain of researches here and abroad which are still in progress. A few of them are indicated in the following discussion.

It was noted during World War I that straight run gasolines from certain crudes had less tendency to knock and was better as aviation fuel than other gasolines.[14] Some years later (1927) the high anti-knock value of 2,2,4.trimethyl pentane or "isooctane" was discovered and its use as an anti-knock standard recommended by Graham Edgar.[6] These facts led directly to a study of the anti-knock values of all the hydrocarbons boiling within the ordinary gasoline range. This work involved the synthesis of nearly 300 pure hydrocarbons and is still going on and now includes the olefins. This has largely been the work of Dr. Cecil E.

Boord and his assistants as regards the synthesis of these hydrocarbons, and Wheeler G. Lovell and his associates in the study of their engine performance. This work in turn led to a vast amount of research on the theory and chemical mechanism of the oxidation of the hydrocarbons in automotive engines, and the function of TEL, and other knock suppressors and knock promoters.

Study of the oxidation of hydrocarbons has been greatly extended in recent investigations by Boord and his associates as applying not only to motor fuel but also hydrocarbons used as fuel in jet engined planes. Two schools of thought have developed in the course of these oxidation studies, one group headed by English authorities have employed kinetics in interpreting the results of oxidizing simple hydrocarbons such as methane and ethane.

The other group has been interested in discovering what the initial and intermediate products are in the oxidation of more complex hydrocarbons. The latter group have carried out a vast amount of research in this field and includes scores of men who have done important work. E. W. J. Mardles suggested in 1931 that alkyl hydroperoxides were first formed in the combustion of motor fuels. A. D. Walsh indicated that the initial oxidation product in the combustion of 2,2,4-trimethylpentane, or "isooctane," was the hydroperoxide formed at the tertiary C-H group. Evidence of the formation of alkyl hydroperoxides, R-O-OH, in internal combustion engines has recently (1953) been furnished by Malmberg, and the series of intermediate products of the oxidation of particular hydrocarbons is being investigated by C. E. Boord and his associates.

Other Researches

Other researches of particular importance in this field include those of H. A. Beatty, G. Edgar, F. F. Rust, W. E Vaughan, M. R. Barusch, J. R. Payne, Per Frolich, N. C. Robertson, P. Wiezevich, and the English workers W. A. Bone, D. T. A. Townend, A. Egerton, and D. M. Newitt.

The partial oxidation of hydrocarbons, industrially, started with the oxidation of natural gas mainly to formaldehyde and methanol in 1927 at Tallant, Oklahoma, in a plant of the Cities Service Company.[17] More recently the partial oxidation of propane and butane mainly to formaldehyde, acetaldehyde, acetone, propylene oxide, methanol, *n*-propanol, acetic, propionic and butyric acids, is now carried out by the Celanese Corporation in two plants in Texas and another in Canada.

DR. VLADIMIR N. IPATIEFF. A pioneer in the study of catalyzed reactions many of which have been developed into well known refinery processes.

DR. FRANK C. WHITMORE. As Dean of the School of Chemistry and Physics at Pennsylvania State College he greatly increased our knowledge of hydrocarbon reactions.

DR. VAN H. MANNING, Director of Research, American Petroleum Institute when the API program of fundamental research was planned and started, in 1925.

Important Contributors to Research in Petroleum Chemistry

The production of formaldehyde from this source in the U. S. now exceeds that from all other sources.

The study of motor fuels led to considerable investigation of the autoxidation of cracked gasoline with the formation of so-called gum. Here also the formation of peroxides was found to be the initial step in the process. During World War I it was learned that certain substances strongly inhibited the autoxidation of certain aldehydes, and in the middle 1920's a variety of excellent anti-oxidants were found which effectively inhibit the autoxidation of cracked gasoline, and subsequently such gasolines no longer required drastic refining methods to minimize gum formation during storage.

Need for high octane engine fuel for airplane engines was much more pressing than that for ordinary automotive engines. The work of Midgley and Boyd,[14] G. Edgar, H. A. Beattie, C. E. Boord, W. G. Lovell and others showed at a comparatively early date that certain hydrocarbons had very high antiknock values. "Iso-octane" or 2,2,4.-trimethyl pentane and "triptane," or 2,2,3-trimethylbutane were at the top of the list. There were good and sufficient reasons why the aviation fuel problem could not be solved merely by the use of large additions of tetraethyl lead. "Isooctane" and "triptane" were greatly desired for blending in aviation fuels and considerable effort was made to find practical methods for the synthesis of these hydrocarbons. In the case of triptane no good process for its production was found, but some "isooctane" was produced industrially by the polymerization of isobutylene and hydrogenation of the diisobutylenes, but the potential production of isooctane in this way was quite inadequate.

Alkylation

Prior to the outbreak of World War II several research groups were working independently along lines which were to culminate in 1939 practically simultaneously in the discovery of alkylation, mainly of isobutane and butenes to give a mixture of saturated branched chain octanes and other hydrocarbons having a very high octane value. This is now of course a familiar story. The research background is not so well known.

The discovery was being approached along several different lines. It had long been known that aromatic hydrocarbons were alkylated by olefins and by alkyl halides by means of aluminum chloride or concentrated sulfuric acid. In 1927 Ormandy and Craven[15] discovered the formation of saturated hydrocarbons, so-called hydropolymers, from pentenes by the action of concentrated sulfuric acid, an observation later confirmed and considerably extended by Ipatieff and Pines. In 1935 Ipatieff and Grosse[11] described the alkylation of isoparaffins by olefins by means of aluminum chloride, and they are usually credited with this discovery.

Industrial alkylation of isobutane was not started however until after the publication of the fact that concentrated sulfuric acid was an effective reagent for this purpose, this being published in 1938 and 1939 in two memor-

able papers by S. F. Birch, A. E. Dunstan, F. A. Fidler, F. B. Pim and T. Tait.[2] It was subsequently revealed that G. H. Visser, in the Shell laboratory in Holland, was working on this type of alkylation three years before, in 1936. In the patent interference proceedings which followed, it appeared that five different companies were doing work along this line in 1939, or before. Also in 1936, F. E. Frey and H. J. Hepp[7] described the thermal alkylation of propane and isobutane by ethylene, operating at high temperatures and pressures.

In 1946 there were 60 alkylation plants in operation, 32 employing sulfuric acid, 27 using hydrogen fluoride and one the aluminum chloride method. Alkylate remains one of the major essential components of high octane aviation gasoline.

These alkylation processes required great quantities of isobutane, some of which was separated by highly efficient fractional distillation of natural butanes, but it is also made by the isomerization of n-butane by aluminum chloride, the research foundations of this process having been provided long before in the study of aluminum chloride as a catalyst in hydrocarbon reactions.

The alkylation of aromatics by olefins, formerly of little interest, is now industrially of great importance, benzene being alkylated with ethylene to ethyl benzene, which is catalytically dehydrogenated to styrene, and benzene is also alkylated with propylene to cumene, which was an important component of aviation gasoline and is now the raw material for the recently industrialized process for making phenol and acetone.

Catalytic Processes

Catalytic processes have recently made many innovations in both refinery processes and in the manufacture of chemicals from hydrocarbons. Catalytic cracking was discussed in the first article of this series.

There is much evidence that petroleums were formed by the action of acid silicate catalysts in the natural rock formations in contact with the organic source material, probably fatty oils or fatty acids and that the intermediate heavy bitumen-like oils have been further modified to typical petroleums, during the course of time, by the same means.[5]

However, the first use of a catalyst in petroleum processing was probably the continuous refining of cracked gasoline by Fuller's earth, developed by T. T. Gray in the 1920's. This process continuously and catalytically polymerized the more highly unsaturated hydrocarbons which are believed to be mainly responsible for gum formation. The discovery of very effective oxidation inhibitors greatly lessened the importance of the Gray process.

Many of the catalytic processes now widely employed in todays refineries were due very largely, directly or indirectly, to the research work of Vladimir N. Ipatieff, who came to this country in 1931 through the influence of Dr. Gustav Egloff. Here Ipatieff was assisted at one time or another by men who later carried on important research of their own on catalytic and other processes. This list includes Herman Pines, A. von Grosse, V. Haensel, Louis Schmerling, V. I. Komarewsky, R. E. Schaad, J. A. Chenicek, and B. B. Corson.

The catalytic processes now employed in synthetic reactions and petroleum processing, in addition to catalytic cracking, include the polymerization of by-product gases from cracking to gasoline by phosphoric acid on an inert solid carrier, dehydrogenation including hydroforming and platforming, and isomerization. Also, in the general sense of the term, hydrogen fluoride, aluminum chloride and sulfuric acid are catalysts in alkylation processes. These processes are well known and need not be described here. All were products of research and were favored by a background of earlier published investigations which in many cases has a bearing on the validity or scope of the many special patents dealing with these developments.

It is impossible to note these research backgrounds in detail and to mention them does not detract in any way from the importance of the work which resulted in new data and improvements important to the industrial operation of these processes. These research foundations are always scrutinized diligently in every patent infringement suit. However, the main purpose in mentioning them is to indicate the trends in modern industrial research, starting from older published scientific research.

Thus the catalytic dehydrogenation of cyclohexanes over platinum and palladium catalysts at 200-300 C to aromatic hydrocarbons has been known since 1911. Although the results of many researches along this line were published by N. D. Zelinsky and others, after 1911, these catalysts were generally believed to be impractical for use with petroleum oils, until very recently. In the mid-1930's promoted chromium oxide and molybdenum oxide catalysts had been developed and found to be very effective.

The need for good catalysts for the production of aromatics and for the dehydrogenation of butanes to butylenes and further dehydrogenation to butadiene, ushered in by World War II, brought a flood of new work from many laboratories and new effective catalysts. However, a good start and much valuable research was done prior to the war, without which foundation work the accomplishments along this line during World War II would certainly have been handicapped and delayed.

Another catalytic process which has received much attention in the last few years, is the conversion of synthesis gas, carbon monoxide and hydrogen, to gasoline, known in Europe where it was first developed as the Fischer-Tropsch process. In Europe the synthesis gas was made from coal and the operation was based mainly on the work of F. Fischer, H. Tropsch, H. Koch and H. Pichler. The year 1951 marked the twenty-fifth anniversary of the first public announcement of this synthesis, and the first commercial plant was built in 1935. In the United States one commercial development was begun several years ago (1947) at Brownsville, Texas, converting natural gas to synthesis gas. The catalyst employed at this plant was iron oxide promoted by caustic potash, similar to the catalyst commonly employed in ammonia synthesis, and under the conditions of operation this material is changed to a mixture consisting chiefly of iron carbides, iron oxide and a relatively small amount of metallic iron. The American development has been under the direction of P. C. Keith.[12]

In this connection it is worth noting a progressive increase in the cost of natural gas for industrial purposes in the Gulf Coast area which affects many chemical plants using it. About ten years ago dry natural gas was sold to carbon black manufacturers in localities close to the gas fields at prices as low as 0.9 cents per 1000, and gas for industrial purposes was commonly available at 5 to 6 cents per 1000. Last year new contracts called for as much as 17 cents per 1000. Also refinery by-product gases including cracked gases and C_3 and C_4 mixtures were usually available at local fuel value. The rise in basic fuel values and the increased demand for ethane, propane, butanes, propylene and butenes for alkylation and chemical manufacture has materially increased these costs. This substantial increase in the price of natural gas in the Southwest has not been caused by threatened scarcity, for with deeper drilling for oil the known gas reserves have been

greatly increased in spite of the greater consumption and the greater distribution through long-distance pipe lines.

Research Related to Manufacture Of Chemicals From Hydrocarbons

Several processes for conversion of hydrocarbons to chemical derivatives have been discussed briefly in the foregoing pages.

Most of the earlier industrial venture into the manufacture of chemicals from natural gas or petroleum hydrocarbons had the advantage of very low raw material costs, based essentially on equivalent local fuel values, and most of the processes employed were based very largely on known, simple hydrocarbon reactions. Little or no chemical research was required although considerable pilot plant work was invariably necessary to establish optimum operating conditions and the best materials for the construction of apparatus. *The importance of such pilot plant work and of the attendant chemical engineering cannot be over-stated.** For example the first isopropyl alcohol to be made commercially from propylene by the sulfuric acid route, is reported reliably to have been more than 60 cents per gallon but this alcohol is now made at a lower cost than any other alcohol.

Soon after about 1925, however, chemicals that could be made from natural gas and petroleum hydrocarbons by methods based directly on long known and relatively simple chemistry, were being commercially made and new research in this field was undertaken, particularly by the Carbide and Carbon Chemical Company, the outstanding pioneer in this field; by Shell Development Company and Shell Chemical Company, the Standard Oil Company of New Jersey and its subsidiaries Standard Alcohol Company and Standard Oil Development Company and soon after by other companies including particularly the Dow Chemical Company, Monsanto, Rohm and Haas, Standard Oil Company of California, the Sharples Company, and the Celanese Corporation.

Others have entered this field of manufacture recently using mainly well known processes which can be operated without fear of patent infringement penalties. In recent years a great expansion in the manufacture of synthetic ammonia has been taking place, using natural gas for making synthesis gas and hydrogen. This was based directly on the older synthetic ammonia work of Haber, Claude and Casale and the conversion of synthesis gas from coal, to hydrogen. Several of these plants also make synthetic methanol, following the older method for producing this alcohol, and more recently urea has been added to the list. Another important recent development is the utilization of by-product hydrogen from the cracking of ethane to ethylene, and also hydrogen resulting from catalytic reforming of gasoline or naphthas and the catalytic production of aromatics. The use of such by-product hydrogen for ammonia manufacture represents a substantial economy over converting natural gas to synthesis gas, particularly since the cost of natural gas started its upward trend.

This use of by-product hydrogen illustrates the economic advantage which often results from the dovetailing of processes and this advantage invariably becomes greater as the number of processes increases and production is diversified. This advantage appears to be greater in the chemical industry than in petroleum processing.

A few of the more important chemical developments based on relatively recent research may be noted, including synthetic glycerine and a series of related compounds by the Shell Chemical Company and the Oxo or formylation process, discovered in Germany and which appears to be an outgrowth from the Fischer-Tropsch process. A series of higher alcohols is now being commercially produced from selected olefins, carbon monoxide and hydrogen, under pressure and using cobalt or cobalt carbonyl catalysts.

A large number of chemical products of four or more carbon atoms are being made from simpler compounds by condensation reactions of acetaldehyde, or acetone. Normal butyl alcohol and a series of higher alcohols, glycols and ketones, are being made starting with condensation reactions. The list of such compounds is impressive and their manufacture has been based on research although many of the reactions involved are not new.

Fundamental Research

Coincident with the research activity relating to petroleum processing and chemical manufacture from hydrocarbons, there has been a great increase in research interest in the field of aliphatic hydrocarbons on the part of university workers.

The fundamental or theoretical research done in recent years by this group has already been of the greatest value, being largely responsible for our present knowledge and better understanding of the mechanisms of reactions involving nonbenzenoid hydrocarbons. The work of the late Frank C. Whitmore was outstanding in this particular field and many of his graduate students are now well known for their work in petroleum chemistry. The work of C. E. Boord on the synthesis of hydrocarbons and study of oxidations has been mentioned. A great many others in American universities have made important contributions in recent years to the fundamental chemistry of the nonbenzenoid hydrocarbons. In former years, however, prior to about 1925, there was little or no interest in this field of chemistry among university people.

One of the greatest factors in bringing about the increased interest in hydrocarbon chemistry was undoubtedly the establishment, in 1925, of the now well known program of fundamental research relating to petroleum sponsored by the American Petroleum Institute. This program was originally made possible by bequests from John D. Rockefeller and the Universal Oil Products Company. In the brief,[4] prepared by the writer in 1924 for Dr. Van H. Manning, giving reasons for basing the program on fundamental research, it was assumed that by establishing such researches in universities, by grants for research assistants, centers of activity would be created and that these research centers would have a *continuing* interest in petroleum and particularly in petroleum chemistry.

Any research gains in effectiveness with its continuity. This assumption has been well confirmed. Researches thus initiated, supply basic scientific information and theory which industrial research workers use almost daily, and these university research centers have supplied a great many of the trained graduate students needed by the petroleum and chemical industries.

Dr. Van H. Manning was director of research of the American Petroleum Institute after World War I and after several years of fruitless effort in attempting to set up a research program on projects having practical or industrial aspects, he was quick to see the advantages and freedom from objections of a program dealing only with fundamental research. The plan was endorsed by a special temporary committee composed of W. D. Bancroft, B. T. Brooks, George A. Burrell, Hans T. Clarke, James B. Conant, Wm. F. Faragher, John Johnston, James F. Norris, Charles L. Reese, Hugh Taylor and W. R. Whitney, called together on March 1, 1924 by Dr. Manning for that purpose. Shortly after the funds mentioned above became available the task of selecting and approving specific projects was turned over to a committee of the National Research Council. This

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committee was composed as follows:

Division of Physical Sciences: L. H. Adams, Geophysical Laboratory, Carnegie Institute of Washington; Hugh S. Taylor, Professor of Physical Chemistry, Princeton University; R. A. Millikan, Director of the Norman Bridge Laboratory of Physics, California Institute of Technology.

Division of Chemistry and Chemical Technology: Benjamin T. Brooks, Consulting Chemist, 59 East 41st Street, New York; William J. Hale, Chairman of the Division, National Research Council; James F. Norris, Professor of Organic Chemistry, Massachusetts Institute of Technology.

Division of Geology and Geography: E. DeGolyer, Consulting Geologist, 65 Broadway, New York; K. C. Heald, Geologist, Gulf Oil Companies, Pittsburgh, Pennsylvania; David White, Chairman of the Division, National Research Council.

Representing the American Petroleum Institute: R. L. Welch, General Secretary; R. P. Anderson, Technologist; Dr. Van H. Manning, Former Research Director, American Petroleum Institute.

The committee named Dr. J. F. Norris as chairman. This committee served in this capacity for about three years when the API assumed these functions. It is no longer necessary to "sell" the idea of the value of such a research program or detail its far reaching benefits.

Some of the researches begun by this program in 1926 are still being continued, and confirming the assumptions made in the brief noted above, many universities and technical schools continue to carry out interesting and valuable petroleum research, including particularly Pennsylvania State College, Ohio State University, the University of Texas, California Institute of Technology, the Carnegie Institute of Technology, and the Massachusetts Institute of Technology. The API has set up several advisory committees for the research projects now being carried on and most of the more important oil companies are represented on these committees. Since the original program was begun many times the sum given by the first donors has been expended in the continuation of the program.

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★ ★ ★

Plant Aid

Shut-In Pressure of Gas Well in Relation to Squared Pressures

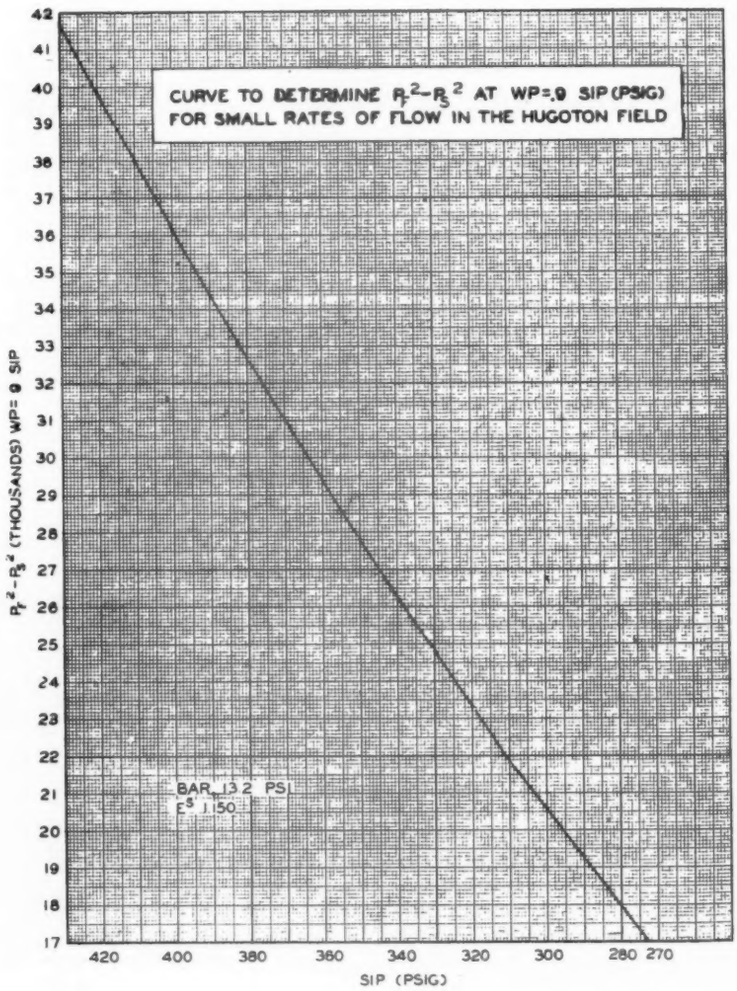
WAYNE B. SMITH[1]

The attached chart relates the shut-in pressure (psig) of a gas well to the difference in squared pressures ($P_f^2 - P_s^2$) wherein the working pressure (psig) is equal to 0.9 of the shut-in pressure. This curve and the back pressure curve of the individual well are used to determine the flow rate that will reduce the working pressure of a well in Hugoton field to 0.9 of the well's shut-in pressure at the end of a 72-hour flow period. As a working pressure equal to the 0.9 of the shut-in pressure is one of the requirements of the official deliverability test in Hugoton field, the curve is a rapid means of determining the proper flow rate for the annual deliverability test.

The assumptions upon which the curve is based are as follows:

1. Atmospheric pressure is 13.2 psia.
2. The weight of the gas column factor is 1.150.
3. The pressure drop due to friction in the casing is negligible.

[1]Natural Gas Department, Dumas, Texas.



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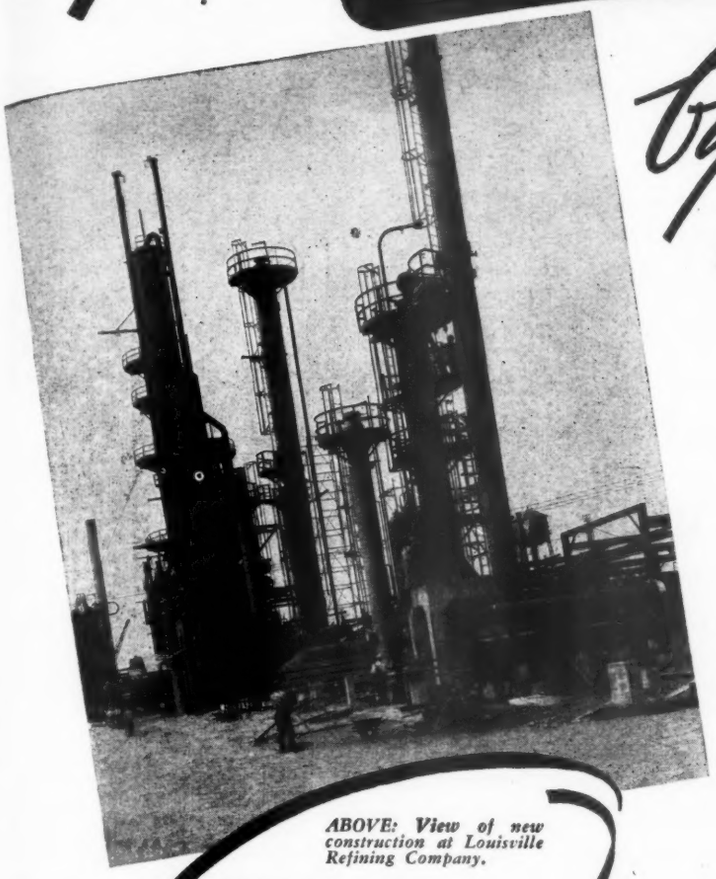

ABOVE: View of new construction at Louisville Refining Company.

BELOW: Some of the many Shell and Tube Exchangers.

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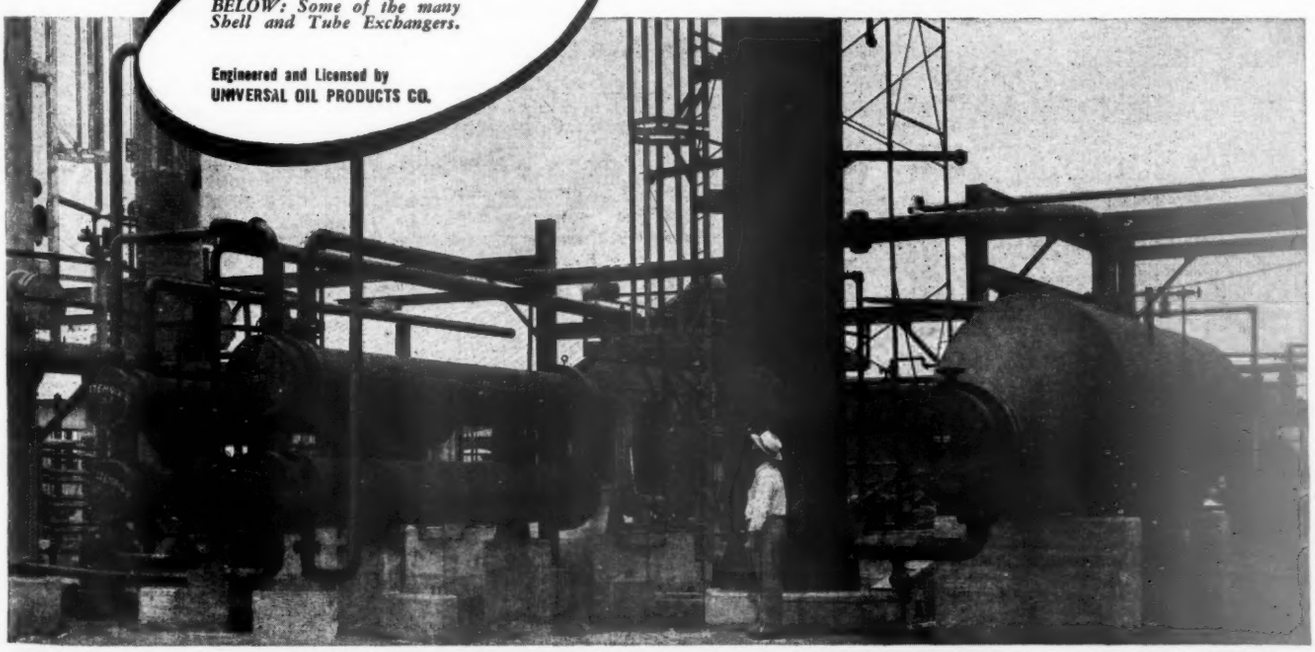

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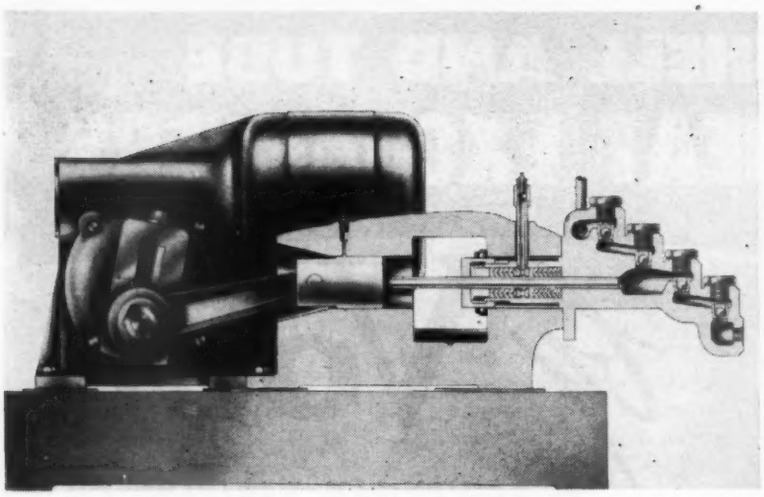

FIG. 1. Milton Roy motor-driven simplex pump. Liquid end is cut-away to illustrate exclusive step-valve construction.

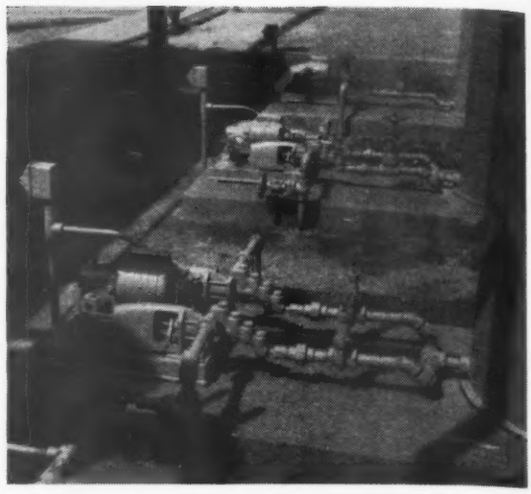

FIG. 2. Lime pumps to boiler plant in field processing plant of a large southwest refinery.

Installation and Maintenance of Controlled Volume Pumps

Proper installation and maintenance schedules assure trouble-free operation

B. BERTOLET*

Long service life in a controlled volume pump is a function of at least two variables: Care in installation and preventive maintenance. Controlled volume pumps are actually metering devices designed for precise pumping of fluids with an accuracy of one per cent. Whether they are employed as single units in a shot-feed or proportional feed system, or as final control elements in automatic control systems, they are extremely important links in the over-all control system. In view of this fact, the need for proper installation and maintenance of controlled volume pumps cannot be over-emphasized.

Installation

The pump manufacturer's instructions should be studied, and all suggestions contained in these instructions should be carefully followed before any pump is installed. Instructions on the lubrication of motors, gears, and other parts are all very important. High unit pressures, which occur in the reduction gears, require the best lubricants to prevent metal contact and to dissipate the heat generated during operation. Packing lubricants are highly important, and specialized types, as recommended for the specific application, should be used exclusively.

Particular attention should be given to both suction and discharge piping. Tubing, either metal or plastic, because of its smooth inner surface and the fact that it can be formed into sweep bends around obstructions, should be considered for the suction line. Should standard pipe be necessary, the number of fittings that are used must be kept to a minimum in order to reduce pressure losses. This is very important when there is a suction lift involved, or when pumping a liquid that is close to its boiling point.

Suction Piping. In installation, care must be taken to safeguard against certain conditions that can cause a considerable loss in pumping efficiency along with erratic operation. When there is a leak in the suction line, for example, or if the packing is improperly adjusted, air can enter the suction system. In addition, when the temperature of a liquid being pumped is too close to the boiling point, it will "flash" into vapor and the displacement chamber will not be completely filled with liquid on the suction stroke. Any or all of these conditions may cause "water hammer" in large size pumps, operating at the higher speeds, with resulting serious damage to the pump and discharge piping. On the suction stroke the chamber fills partially with liquid and partially with vapor. On the discharge stroke, the plunger moves forward, collapsing the bubble of vapor. By the time maximum velocity is reached, the plunger strikes the liquid in the chamber. The resulting shock wave vibrates the piping system and may result in pressure waves that, in time, can cause failure of the piping or of the pump operating mechanism. To eliminate this problem, sufficient suction head must be provided at the suction port of the pump at the time of installation, in order to insure a full displacement chamber on each suction stroke.

Discharge Piping. Discharge piping must also be properly installed if good results are to be obtained. Adequately sized pipes should be selected to prevent build up of excessive pressures on the discharge stroke of the pump. These pressures obviously place an excessive load on the pump mechanism.

Controlled volume pumps will not operate properly unless they work against positive discharge pressure. Pressure on the discharge side must be greater than on the suction side of the displacement chamber, in order to properly seat the free ball checks. When it is necessary to pump from a region of higher pressure into one of lower pressure, an artificial positive head, in the form of a vented riser, or a back pressure valve, must be provided. (Fig. 2). The vented riser, which prevents siphoning action, is simply a vertical extension of the dis-

*Service Manager, Milton Roy Company.

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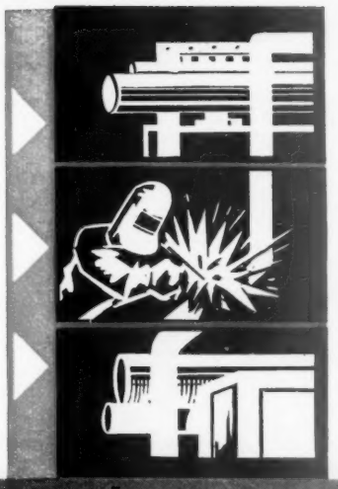

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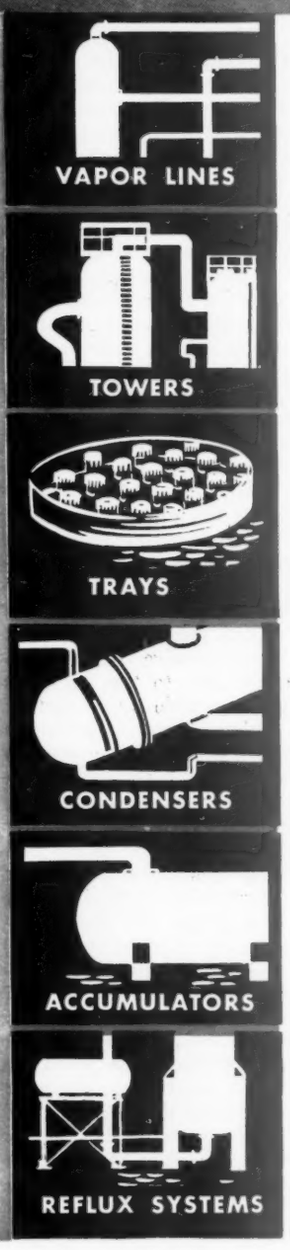

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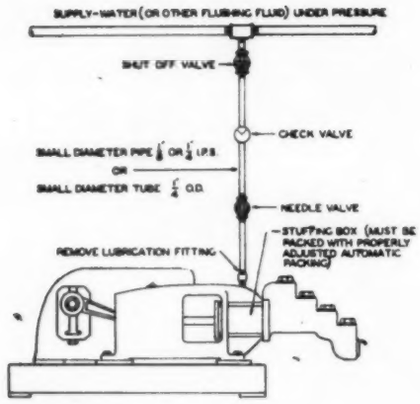
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CHECK VALVE
SMALL DIAMETER PIPE ¼ OR ⅜ I.P.S.
OR
SMALL DIAMETER TUBE ¼ O.D.
NEEDLE VALVE
STUFFING BOX (MUST BE PACKED WITH PROPERLY ADJUSTED AUTOMATIC PACKING)
REMOVE LUBRICATION FITTING

FIG. 3. Internal flushing connection.

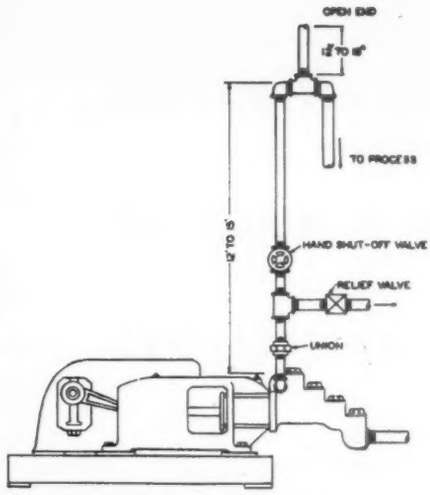

FIG. 4. Vented riser installation.

charge pipe into an open tee. The other side of the tee goes to the process. This device, which provides an artificial discharge head, is practically maintenance-free.

Another method involves the use of a back pressure valve. These valves are usually spring-loaded diaphragm relief valves, which have been especially designed for back pressure service. They are designed to function properly on each pumping stroke, rather than only for emergency relief of pressure surges. An important reason for using these valves is that the diaphragm protects the spring from the corrosive action of the fluid being pumped. In addition, particles cannot clog the spring.

As controlled volume pumps are positive displacement types, they can build up a tremendous discharge pressure in one or two strokes, long before a thermal overload protection, or similar device in the motor circuit, becomes effective. Very serious damage to the pump, discharge line, or process equipment can occur if the discharge line is obstructed. To prevent this damage, discharge lines should be equipped with a properly designed relief valve. Proper location of the relief valve is on the discharge pipe, as close to the pump as possible and *always* before any shut-off valve. The outlet of the relief valve should be piped back into the suction tank, or to a drain with the end of the pipe visible at all times. In this way, leakage of the relief valve may be easily detected and corrected. For safety reasons, a check valve is recommended for use in the discharge line near the point where the line enters the boiler or process vessel.

Hand shut-off valves should be provided adjacent to the pump, in both suction and discharge lines. Pipe unions in these lines (on the pump side of the shut-off valves) will facilitate servicing the liquid end in those cases where it must be removed from the pump frame.

Packing. Packing in these pumps must be given a "break-in" run before actual pumping load is applied. This is best accomplished by releasing the packing, pulling it up just a little bit more than "finger tight," and injecting packing lubricant into the lubrication fitting that is provided. Follow the specific packing lubrication instructions furnished with the pump. The packing gland should then be pulled up tightly, to "set" the packing in the stuffing box. Keep the packing loaded for several minutes to allow the packing to "flow" into position in the stuffing box. Release the packing and draw up the gland a little more than "finger tight." Operate the pump dry, that is, without pumping load, for about ½ hour, with a few drops of light oil occasionally applied to the plunger where it enters the stuffing box.

The pump should then be placed in operation, and adjusted for proper chemical feed. If there is leakage at the gland, tighten the packing *very gradually* over a period of several hours. The first 24 hours of operation are very critical, as far as packing life is concerned. If the packing is pulled up too tightly, it will overheat and decompose rapidly. If it is very carefully adjusted during this critical period, it will develop a good running surface, thereby greatly extending its life.

If certain phosphate solutions, solutions of limited solubility or slurries are to be pumped, packing and plunger life will be considerably increased if an internal flushing connection is used, with a "V" or "Chevron" type of packing. (Fig. 3). These solutions tend to concentrate in the packing and to precipitate abrasive crystals which "score" the plunger and result in rapid packing wear. Slurries tend to accumulate fine abrasive particles in the packing, with the same result. The internal flush connection prevents these accumulations by continuously flushing the stuffing box through the lantern ring. On the discharge stroke of the plunger, some of the liquid that is being pumped is forced back into the packing. On the suction stroke, as the "V" packing relaxes, a little of the water introduced by the internal flush connection flows from the lantern ring along the plunger into the displacement chamber, flushing out the abrasive slurry particles, or preventing the precipitation of crystals from the solution. The flow of flushing water amounts to only a few drops per minute. The proper way to make this internal flushing connection is illustrated in Fig. 3. It is essential that "V" packing be used with this internal flush connection, and it must be properly adjusted to allow normal "flexing" to take place.

Preventive Maintenance

If the pump has been properly installed, the actual maintenance that is required is essentially routine lubrication and replacement of worn parts. Lubrication should be effected in accordance with a definite schedule, determined by the specific plant operations. Proper and adequate lubrication will greatly extend the life of a controlled volume pump.

Care of Packing. It has been emphasized that improper installation and failure to properly break in the packing can cause excess leakage and, if the liquid is corrosive, premature failure of the pump. Similarly, preventive maintenance extends packing life, thereby contributing to long service life of the pump.

Condition of the plunger is of primary importance in getting maximum service from packing. Obviously, packing will not last long if it is used with a scored plunger, as scoring will cut the packing as rapidly as it is tightened. Light scoring may be reduced by polishing the plunger in a lathe. The plunger should be replaced if it is badly scored.

The fit of the crosshead-plunger assembly into the pump frame is also a detail which should be checked when packing is to be replaced. If this fit is too loose, weight of the plunger is supported by the packing instead of the crosshead. This condition will rapidly wear the packing, and allow the plunger to drag on the lantern ring or throat of the stuffing box. Result will be plunger scoring and rapid deterioration of the packing. If there is evidence of wear on the plunger guiding surfaces (crosshead and/or pump frame) they should be machined or replaced. Whenever packing is replaced, it is essential that the break-in instructions be carefully followed.

There are two general types of packing used in these pumps, (a) automatic, self-sealing, "V" or "Chevron" types, and (b) compression types. Substitution of one type of automatic packing for another will usually cause no trouble, but an automatic packing set should not ordinarily be replaced with a compression set, or vice versa, without consulting the pump manufacturer. Packing included as original equipment is carefully selected from many available types as the best for the particular application.

Packings of square or round cross sections, which must be firmly compressed in the stuffing box, are known as compression types. These are made of many compositions, each suited for use with a definite group of chemicals. They depend for their proper functioning on compression in the stuffing box, but if too tightly compressed, they will over-

heat and disintegrate rapidly. Plungers in these pumps are usually one of the austenitic stainless steels, which are rather soft and, if operated with a packing that is excessively tight, will inevitably become "scored." This condition also places an excessive load on the motor and gears.

Automatic packings, "V" or "Chevron" shaped, depend for their operation on hydraulic pressures in the displacement chamber which act on their special shape. Their design causes the sealing edges to expand into close contact with the plunger and the inside surface of the stuffing box on the pressure stroke of the pump, thereby effecting a seal. When the pressure in the displacement chamber drops on the suction stroke, the packing relaxes, easing the load on the operating mechanism. Automatic packing must never be operated so tightly that it cannot properly flex. All desirable operating characteristics will be lost and wear will be accentuated. It is seldom necessary to operate "V" packing more than "finger tight," except under extreme pressure conditions.

Replacing of Packing

1. Thoroughly clean the stuffing box of old packing and grease. Check the plunger for "droop" (poor fit of the crosshead guide caused by wear), and "scoring" or pitting by corrosion. Install new plunger or crosshead, or both if inspection shows this to be necessary.

2. Thoroughly cover each piece of packing with the lubricant recommended by the pump manufacturer. Place one packing section at a time in the stuffing box. If required, be sure to locate properly adapters at the bottom and top of the packing, and on both sides of the lantern ring (if a lantern ring is used). Tamp each piece of packing firmly in place before adding the next piece. If the rings are split, stagger the joints so that they will not be in line. Locate the lantern ring carefully, preferably with the end toward the pressure side just under the lubrication fitting. It will move up as the packing is "set" and adjusted. Fill the stuffing box with packing to about ¼ in. of the top. This will allow the gland to enter sufficiently to provide proper guiding.

3. Place the gland in position. Pull up evenly on the gland until the packing is under heavy compression. Hold this pressure on the packing for several minutes to allow it to "flow" into position in the stuffing box.

4. Follow the packing break-in instructions previously described.

Since World War II, many new packing compounds have become available, including corrosion-resisting plastic materials. They are considerably more expensive than the usual packings, but their almost complete chemical inertness makes it economical to use them in many cases. Special instructions are usually provided by manufacturers of such packing, and these instructions should be followed strictly.

Checking the Pump. If there is a relief valve on the discharge side of the pump, with a hand shut-off valve in the discharge line beyond it, it is usually possible to close the hand shut-off valve, and to operate the pump against the relief valve, measuring the volume of liquid pumped for some definite number of pump strokes. Theoretical capacity can be easily determined by multiplying the area of the plunger in square inches by the stroke length in inches, and this product by the number of strokes used in the test above. This calculation gives the theoretical capacity of the pump in cubic inches for the number of strokes used.

It is usually impossible to obtain full theoretical capacity from these pumps, because of "slip" (slight losses which occur in valve seating), the compressibility of many liquids, and packings used. The ratio between actual capacity, as determined by the above test, and theoretical capacity, is termed volumetric efficiency. This ratio varies with pump size, the liquid being pumped, and many other conditions. In smaller pumps, with capacities of approximately 25 gal per hour operating at pressures below 1000 psi, a volumetric efficiency of 85 per cent or better (based on pumping water at room temperature) should be obtained in the above test. If the efficiency is low, check the valves, valve seats, and packing. If these are in good condition, check the suction line. If possible, disconnect the suction line at the pump inlet, and connect this inlet, through a hose, to a bucket of water. Run the above test over again. A considerable increase in efficiency indicates the possibility of an obstruction in the suction line, or air leakage.

Failure of a pump to build up pressure can result from: (1) wear of the valve seats or ball checks, or both; (2) dirt on the valve seats or balls; (3) air leakage in the suction line or at the stuffing box; (4) open relief valve; or (5) insufficient suction pressure. Methods for correcting these troubles are contained in the manufacturer's service manuals. These should be consulted for details on repairs that are required in these cases.

Spare Parts. It is recommended that a standard spare parts group be kept on hand at all times to prevent serious delay in repairs. For pumps of the type illustrated in Fig. 1, this recommended spare parts group consists of the following parts for each liquid end, or pumping cylinder:

3 — Sets of packing (1 set of Teflon).
1 — Plunger
1 — Plunger pin

TABLE 1. Trouble shooting chart.

Sympton	Cause	Remedy
1. Pump won't operate	A. Blown fuse	A. Replace blown fuse
	B. Open thermal overload device in starter	B. Reset
	C. Low liquid level (where low level cutoff is used)	C. Fill tank
	D. Broken wire	D. Locate and repair
	E. Low voltage	E. Determine reason (wiring may be too light)
	F. Discharge line blocked	F. Remove block
	G. Liquid "frozen" in pump	G. Thaw out
2. Pump doesn't deliver rated capacity	A. Starved suction	A. Replace suction piping with larger size, or increase suction head
	B. Leaky suction piping	B. Repair or replace defective piping
	C. Excessive suction lift	C. Rearrange equipment location to reduce suction lift
	D. Liquid too close to boiling point	D. Lower temperature or increase suction pressure
	E. Capacity adjustment incorrectly set	E. Adjust properly
	F. Leaky packing	F. Adjust or replace packing
	G. Pump operating at incorrect speed	G. Check line voltage and frequency against motor nameplate
	H. Worn or dirty valves or seats, or both	H. Clean or replace
	I. Viscosity of liquid too high	I. (1) Reduce viscosity by heating, or other means; (2) Increase size of suction piping; (3) Increase suction pressure
3. Pump delivers erratically	A. Leaky suction line	A. Repair or replace piping
	B. Leaky packing	B. Repair or replace packing
	C. Worn or dirty valve seats, or both	C. Clean or replace
	D. Excessive excursion of ball valves from seats	D. Limit excursion to manufacturers tolerance
	E. Insufficient suction pressure	E. Increase suction pressure: (a) Raise tank leve (b) Pressurize suction tank
	F. Liquid too close to boiling point	F. Reduce temperature or raise suction pressure
	G. Leaky relief valve	G. Repair or replace relief valve
4. Motor overheats Note: Totally enclosed and explosion proof motors operate at higher temperatures than open motors.	A. Power supply does not match motor characteristics	A. Check power supply against motor nameplate data
	B. Insufficient quantity or improper type of lubricant in gear case	B. Check level and type of lubricant. Replace, if doubt exists
	C. Overload caused by operating pump beyond rated capacity	C. Check operating conditions against pump manufacturer's specs
	D. Packing too tight, or improperly lubricated	D. Readjust packing and lubricate if necessary
	E. Pump operating mechanism improperly lubricated	E. Check all lubricating points
	F. Mechanical misalignment	F. Check alignment of all working parts
5. Noisy operation (1) In pump	A. Pump valves	A. Valves must move to open and close, and they will make a clicking noise as they operate. In the larger sized pumps, the ball valves may roll in their cages causing rattling noises. These noises are sometimes amplified by natural resonances in the piping system. They are usually indications of normal valve functioning.
	B. Loose rod bushings	B. Replace worn bushings (and pins if necessary)
(2) In gear reducer	A. Excessive backlash in gears	A. Adjust or replace gears
	B. End play in high speed shaft	B. Shim shaft to minimize
	C. Worn bearings	C. Replace bearings
	D. Lack of or wrong type of lubricant	D. Drain and refill gear case with proper quantity and type of lubricant

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This is considered the minimum spare parts group, and when parts are used for service they should be immediately replaced. If a pump is an essential unit in a process and production would stop if it were shut down, then it is obvious that sufficient spare parts should be carried in maintenance stock to prevent long, costly, shut-downs.

Service Assists. Pumps are occasionally changed from the service for which they were purchased to an entirely different application. This may cause serious damage to the wetted parts, because of the corrosive effect of the new liquid being handled. The pump manufacturer should be consulted before any attempt is made to change the application of any of these pumps.

When communicating with a manufacturer for any reason, be sure that you give him all the pertinent details. Pump serial and model numbers are necessary for proper identification. Most pump manufacturers keep detailed records, by serial numbers, of all pumps that are shipped. Exact engineering details of any pump in the field can easily be determined by reference to these numbers. A rough sketch of the installation, showing liquid levels in tanks, and the length, sizes, and fittings, on both the suction and discharge piping would be extremely helpful to the manufacturer. This information should also include the identity of the liquid being pumped, its temperature, and any other known characteristics.

The pump manufacturer is always ready to assist you with your maintenance problems. There is much wisdom, however, in the well known cliché regarding an ounce of prevention. Preventive maintenance really pays on controlled volume pumps as well as on other type of equipment. Periodic inspection for bearing wear, packing adjustment, and proper functioning of valves will assure the continued accurate performance of pumps in service for which they were intended. * * *

☆ ☆ ☆

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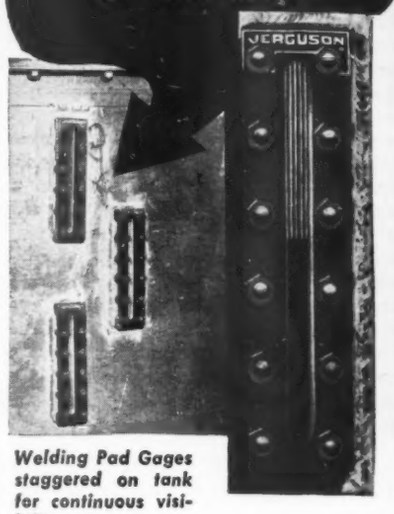

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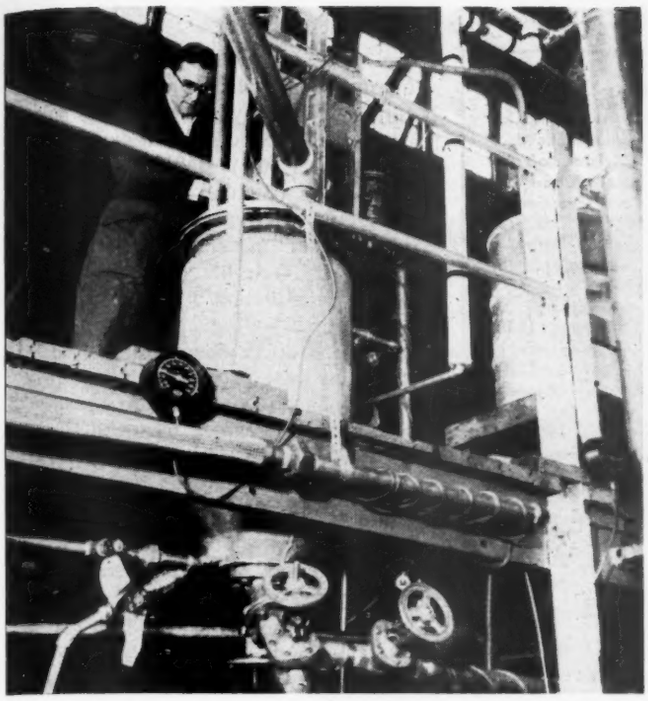

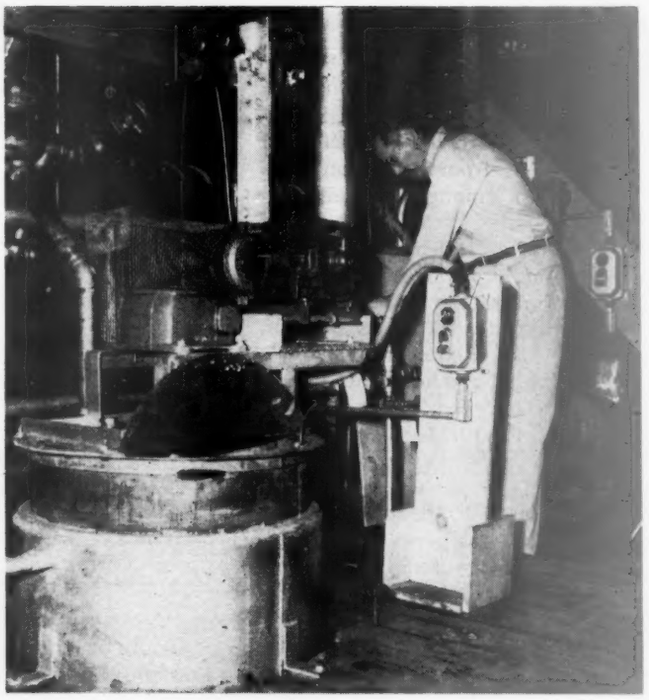

Photos from General Chemical Division, Allied Chemical and Dye Corporation.

FIG. 1. View in sulfonation experimental laboratory, showing kettle and heat exchanger.

FIG. 2. An experimental neutralization kettle, used in sulfonation studies employing sulfur trioxide, SO_3.

Sulfonation of aromatic hydrocarbons has become a major petrochemical tool

SYNTHESIS OF PETROCHEMICALS—7†

EVERETT E. GILBERT

General Chemical Division, Allied Chemical and Dye Corporation

FOR more than a century petroleum refiners have purified various crude hydrocarbon distillates by treatment with sulfuric acid. For nearly this long, mineral white oils have been manufactured by drastic treatment of lubricant fractions with fuming sulfuric acid (oleum). The white oil process yielded organic sulfonates as by-products, and although they slowly found uses—notably as fat-splitting catalysts and as emulsifying agents—refiners until relatively recently regarded the sulfonation process primarily only as a method of purification, and a highly objectionable one at that since sulfur dioxide was liberated and unmanageable tars and sludges were often formed.

About the time of World War II, this attitude for several reasons underwent a reversal and oil companies began to take an increasing interest in the sulfonates per se. Then for the first time the demand for oil-soluble sulfonates began to exceed the supply available as by-product from white oil manufacture. Such sulfonates found major use in the new heavy-duty "detergent" lubricants, the requirements of which have increased steadily. Since the refiner produced the hydrocarbon raw material for such sulfonates, and since he also marketed the final compounded lubricant, he has naturally become interested in the intermediate sulfonation step.

A second type of sulfonate of great interest to petroleum processors is that derived from "dodecylbenzene" prepared by alkylating benzene with polypropylene. By 1951 about 150,000 tons of this sulfonate (100 per cent basis) was produced for use as a household and industrial detergent, wetting agent and emulsifier, having shown a twelvefold increase since 1943. Originally, this hydrocarbon was made by chlorinating kerosine, followed by condensation of the chlorinated kerosine with benzene; this type of operation was of more interest to chemical manufacturers than to petroleum refiners. This view, however, changed radically when it was found that the use of chlorine could be obviated by employing propylene tetramer. Dodecylbenzene is now produced in quantity using the standard unit operations of polymerization and alkylation that have become second nature to petroleum technologists during recent years. Oil companies have therefore supplanted chemical companies as the dominant manufac-

†The text of this article is condensed from a chapter to appear in the forthcoming book "The Chemistry of Petroleum Hydrocarbons," edited by B. T. Brooks, C. F. Boord, S. S. Kurtz and L. Schmerling, published by Reinhold Publishing Corporation.

EXCLUSIVE

turers of this hydrocarbon, and this has naturally led the former to produce and market the derived sulfonate as well.

The trend toward the production of pure chemicals from petroleum ("petrochemicals"), among which are aromatic hydrocarbons including benzene, toluene, and the xylenes, has led to consideration of sulfonation as an established means for converting them to useful derivatives such as phenols. In addition, the oil companies have become substantial producers of sulfuric acid, which may be marketed most profitably in the form of organic sulfonates.

In Table 1 are listed several sulfonates considered to be of actual or potential interest to petroleum processors. The parent hydrocarbons are all closely related in that they are alkylated derivatives of benzene, or — in the case of those isolated as sulfonates during white oil manufacture — of similar structure. In spite of this similarity of chemical structure, sulfonation conditions vary from case to case, as will be explained in more detail in the following sections.

TABLE 1. Products obtainable via sulfonation of aromatic hydrocarbons of petroleum origin.

Hydrocarbon	Product	Uses
Benzene	Phenol, resorcinol	Plastics, chemicals
Toluene	Cresols, saccharine	Plastics, pharmaceuticals
Xylene	Sulfonate	Solubilizing agent
Dodecylbenzene	Sulfonate	Detergents
Lubricant fractions, long-chain alkylated benzenes	Oil-soluble sulfonates	Lubricant additives, emulsifiers
Polystyrene	Sulfonate	Ion-exchange resins, tanning agents

Basic Factors in Sulfonation

The most efficient possible sulfonating agent for aromatic hydrocarbons would be sulfur trioxide, reacting by simple addition according to the equation

$$R \cdot H + SO_3 \longrightarrow RSO_3H$$

For several reasons, however, explained more fully below, sulfur trioxide has until recently been of only slight interest as a practical sulfonating agent.

Sulfuric acid, on the other hand, sulfonates by an equilibrium type reaction as follows:

$$R \cdot H + H_2SO_4 \rightleftharpoons RSO_3H + H_2O$$

These two reagents are at opposite poles respecting their activity as sulfonating agents in a number of ways summarized comparatively in Table 2.

The Author

Everett E. Gilbert is supervisor of organic research for General Chemical Division of Allied Chemical and Dye Corporation. He received both his AB and PhD degrees from Yale University in 1935 and 1938, respectively, joining Tide Water Associated Oil Company as research chemist in 1938. In 1941 he joined Allied Chemical and Dye as research chemist and accepted his present position in 1944. He has 22 patents in various fields of organic chemistry.

Oleum (a solution of SO_3 in 100 per cent sulfuric acid) has proved a practical compromise between these two extremes in actual practice, and is the most widely used industrial reagent for sulfonating aromatic hydrocarbons. The advantages for sulfur trioxide (and correspondingly for oleums) as tabulated in Table 2 (rapid and complete reaction, minimum reactor capacity and absence of spent acid) have become increasingly attractive industrially because of higher labor and fixed capital costs and the desire to obviate waste acid disposal, while the disadvantages (high heat of reaction with consequent decomposition, high viscosity of reaction mixture) can often be overcome by engineering design, proper choice of conditions or use of a solvent. A trend has in fact been noted toward the use of stronger sulfonating agents.

TABLE 2. Comparison of sulfuric acid and sulfur trioxide as sulfonating agents.

Factor	H_2SO_4	SO_3
Reaction rate	Slow	Instantaneous
Heat of reaction	Requires heat for completion.	Strongly exothermic throughout.
Extent of reaction	Partial	Complete
Availability	Universal	Recent (see note)
Spent acid	Substantial	None
By-product formation	Slight	Extensive in some cases.
Reaction capacity	Substantial	Minimum
Viscosity of reaction mixture.	Low	High in some cases.

Note: Liquid form became commercially available in the United States in 1947; previously available as "converter gas" or by distillation from oleum.

The reversibility of the sulfonation reaction (when using sulfuric acid or oleum) has several important practical consequences. First, it follows that means for driving the reaction to completion must be found if good yields are to be obtained. This necessarily involves removal of water if full utilization of both hydrocarbon and sulfonating agent is desired. In cases where the hydrocarbon is stable and relatively low-boiling (such as benzene, toluene or xylene) the water is commonly removed by the passage of excess hydrocarbon through the mixture ("partial pressure distillation"). If the hydrocarbon is high-boiling and of lower stability (e. g. dodecylbenzene) removal of water by this procedure is not practical. In such cases, the hydrocarbon is completely reacted by using a large excess of sulfonating agent.

Second, the reversible nature of the reaction determines which sulfonate isomer will predominate in the reaction product at any given temperature under equilibrium conditions. This depends not upon which position is most easily sulfonated, but upon which isomer is most stable at the equilibrium temperature. This effect is outstanding in the sulfonation of toluene and of naphthalene, and, in the disulfonation of benzene in the meta position (intermediate to production of resorcinol), it is essential to sulfonate sufficiently rapidly or at a low enough temperature to avoid equilibrium formation of the undesired para disulfonate isomer.

A third implication of equilibrium is that it permits recovery of a hydrocarbon from its sulfonic acid by steaming at a critical temperature characteristic of each compound. This approach (selective sulfonation followed by selective desulfonation) has been considered as a possible method for separating hydrocarbons of similar boiling points, for example the isomeric xylenes from petroleum, when physical methods have given difficulty.

Sulfonations are often accompanied by undesirable side reactions, the nature and extent of which will depend upon the structure of the hydrocarbon being sulfonated, the sulfonating agent, and the physical conditions used. Those of major are interest: Sulfone formation, polysulfonation, dealkylation, oxidation and rearrangement. The occurrence of these side reactions in individual cases, and the methods used to overcome them, will be discussed in the following sections.

Most industrial sulfonations are conducted on a batch scale and basically comprise simple mixing of a liquid sulfonating agent (oleum or acid) with the organic compound in a reaction kettle of standard design. When SO_3 is used, it is often introduced as a gas diluted with dry air. A typical batch reactor consists of a jacketed kettle equipped with an efficient agitator,

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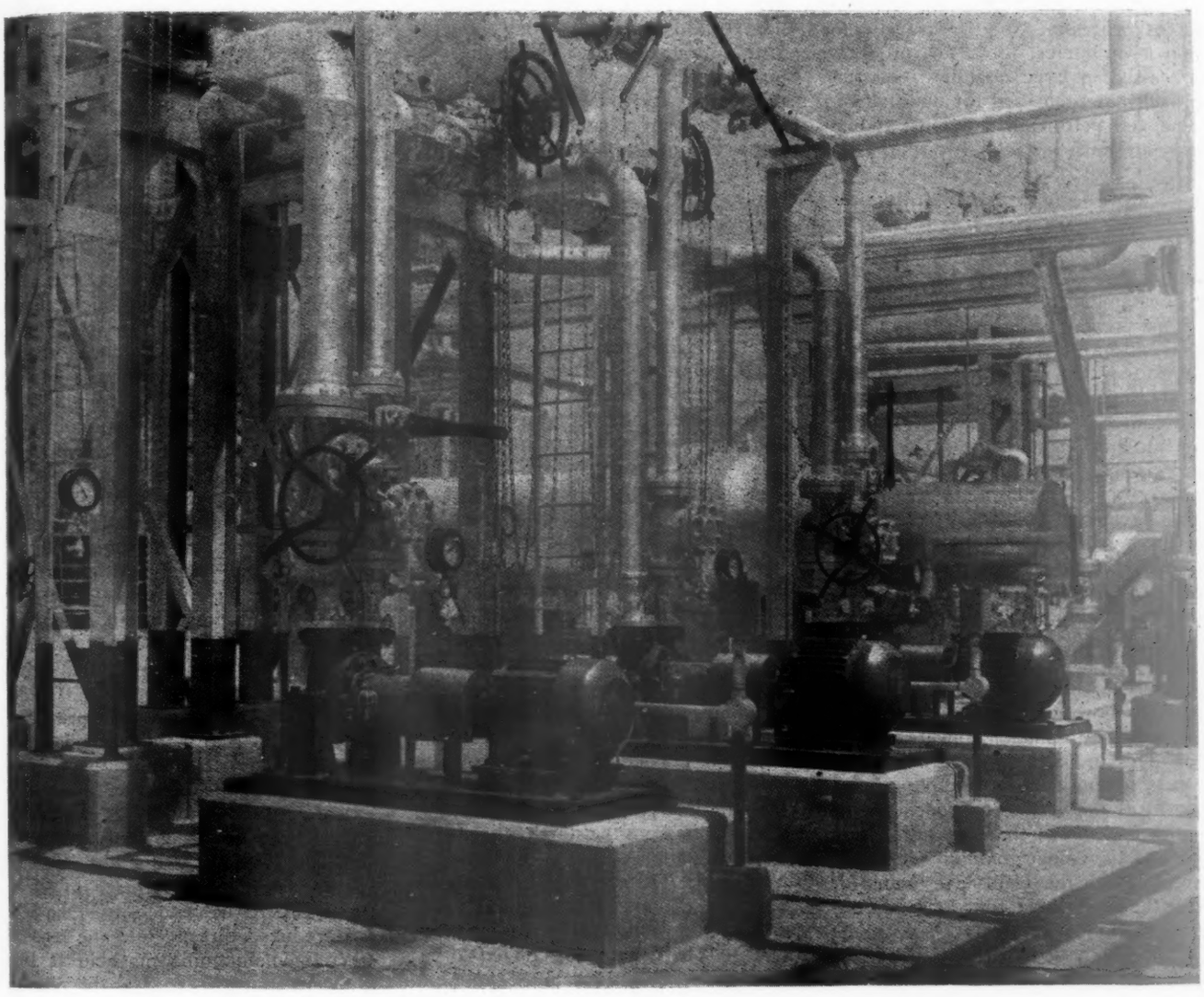

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both of which are essential since many sulfonic acids have high viscosity and heat must usually be applied or removed during reaction. The order of mixing of the reagents varies with different processes. Continuous sulfonation is of interest for a few products processed in large quantity. This approach has been used for dodecylbenzene and petroleum fractions, and in the monosulfonation of benzene.

Sulfonation of Aromatic Hydrocarbons in Practice

Monosulfonation of Benzene. The monosulfonation of benzene is of commercial interest as being intermediate to one process for manufacturing phenol, and to the only established procedure for producing resorcinol. Benzene is now produced from petroleum, and the cumene oxidation process for converting it to phenol is projected for operation by an oil company. Phenol has therefore achieved status as a petrochemical.

The conversion of benzene to phenol was originally accomplished only by the standard sulfonation and fusion procedure. Now, however, there are four processes (sulfonation, cumene oxidation, and two involving chlorination) — all operating on a large scale and all showing about the same overall benzene-to-phenol conversion factor. This unusual situation has led to much speculation as to the relative merits of the various approaches. One study has shown that the sulfonation method is being gradually replaced, even though the plant investment for it is the least of the four.[3] Certain improvements, however, have been made in the sulfonation method, and a second authority feels that "in spite of the development of all the other processes, the sulfonation process is by no means outmoded and, in certain situations, will be best fitted for the needs".[17]

In view of the competitive nature of phenol manufacture, it is somewhat surprising to note that the monosulfonation of benzene with a large excess of monohydrate acid — the simplest but least efficient procedure — should still be used commercially in Germany in spite of the fact that this process is operated on a batch basis and consumes twice the theoretical quantity of acid which must subsequently be removed by neutralization as calcium sulfate. In outline,[5] this operation comprises the addition of benzene (1500 kg.), with cooling, to monohydrate acid (3000 kg., 200 per cent of theory) over a period of 1 hour such that the temperature rises quickly to 60 C, then to 75 C as more benzene is added continuously. The latter temperature is not exceeded as the remaining benzene is added. The reaction is completed by heating to 105 C over a period of 1 hour, and maintaining at this temperature for 4 hours. Spent acid is approximately 83 per cent in strength. Operation of this process on a continuous rather than on a batch basis has been shown — on the basis of laboratory tests — to accelerate substantially the rate of sulfonation. The composition of the reaction product was, however, the same — no improvement being noted in acid consumption.

The low boiling point of benzene makes it well suited to the partial pressure distillation approach for completing the sulfonation—the water formed being removed as excess benzene is vaporized through the reaction mass, thereby giving nearly quantitative utilization both of benzene and acid. This principle is the basis of the well-known Tyrer or Guyot process, by which all the benzenesulfonic acid made in the United States for conversion to phenol is reported to be produced[17].

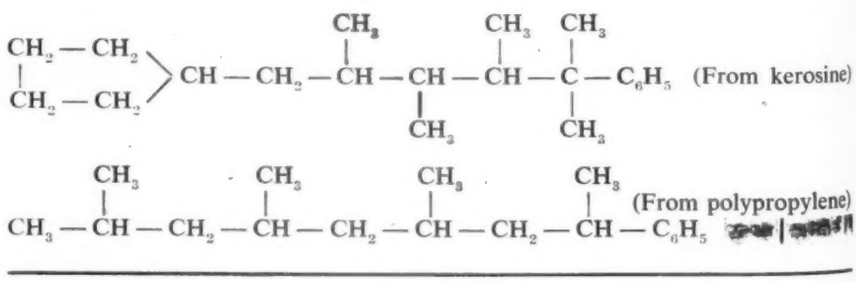
The Tyrer (or Guyot) process has been described.[3] In its original form, it was operated on a batch basis starting with acid of 90 to 92 per cent strength, and requiring a 14-hour reaction time with recycle of 6 to 8 moles of benzene per mole reacted. Substitution of low strength oleum for acid necessitated less removal of water and was found satisfactory from the standpoint of sulfone formation, which would be objectionable. The greatest improvement, however, consisted of continuous operation in a multiple-stage cascade system, which has been calculated to reduce the reaction time to 1.5 hours at 180 C, in a 7 stage reactor using 10 moles of benzene per mole of acid; doubling the reaction time reduced the recycle of benzene to 3 moles per mole reacted. A 6-unit cascade reactor is in commercial operation and has been generally described.[8]

Direct reaction of benzene with SO_3 — without the necessity for water removal as in the Tyrer process — is theoretically the simplest and most direct procedure for preparing the monosulfonic acid:

$$C_6H_6 + SO_3 \rightarrow C_6H_5SO_3H$$

By-product sulfone formation is prohibitively high, however, if this approach is used directly. Indirect reaction, on the other hand, is free of this objection and forms the basis of a third process of industrial interest, namely that developed by Dennis and Bull. It is based upon the observation made by the former that, in the presence of sulfuric acid, benzene will dissolve 2 to 3 per cent of its own volume of benzenesulfonic acid. This process is also designed to operate in a continuous countercurrent flow in a cascade system, benzene being introduced at the bottom and a benzene solution of the sulfonic acid overflowing from the top. Sulfuric acid is added continuously at the top and spent sulfuric acid (77 per cent) is removed from the bottom of the reactor. The spent acid is fortified with SO_3 for reuse, and the benzene is distilled from the sulfonic acid for recycle to the system. Although this procedure is in an overall sense the most efficient possible, since benzene and SO_3 are the only raw materials and no water is removed, the heavy benzene recycle requirement (20 to 30 parts per part reacted) has proved a major obstacle to the commercial success of the process, and apparently it has not been used industrially to any extent. Further study has, however, shown[13] that the reactor efficiency can be increased tenfold and the benzene recycle requirement reduced to 10 to 20 parts per part reacted if (1) the SO_3 is introduced directly into the reactor (thereby maintaining the acid at 100 per cent strength), and (2) the reactor is operated under pressure.

Detergent Alkylates ("Dodecylbenzene"). These hydrocarbons, of which several are marketed with similar molecular weights and chemical structures, may be regarded as monoalkylated benzenes of the general structure RC_6H_5, where R is a long hydrocarbon chain averaging about C12 derived from kerosine or more generally from polypropylene. Possible typical structures for these alkylates are as follows:



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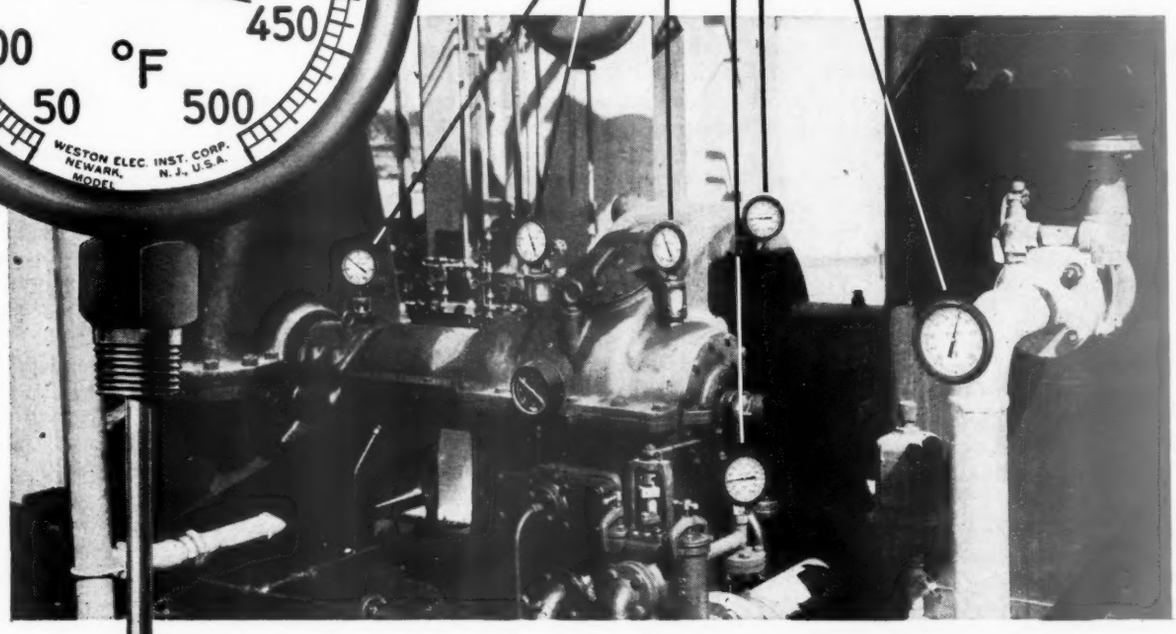

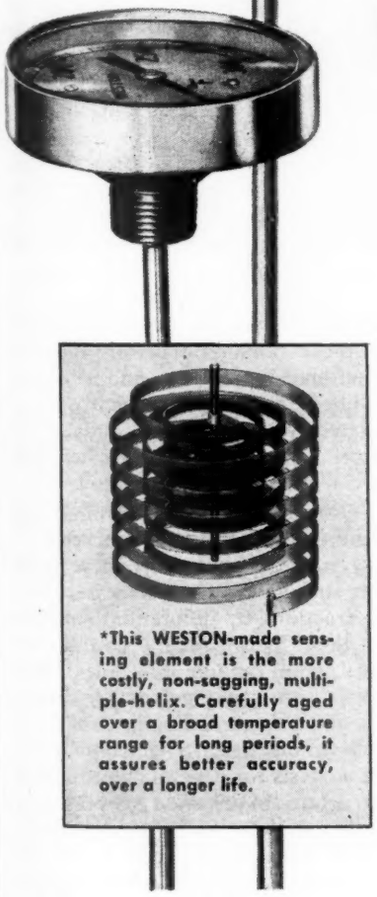

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The sulfonates of these hydrocarbons are marketed in steadily increasing volume as household and industrial detergents and wetting agents.

Early detergent alkylates had structures less favorable for sulfonation, since they tended to decompose during reaction — especially with the stronger reagents. Thus, toluene alkylated with the tertiary dodecyl group (from triisobutylene) underwent disulfonation and dealkylation accompanied by hydrogen transfer, which led to tar formation (giving a dark color) and high unsulfonated oil content producing a sticky final product with an objectionable odor. The sulfonation of these rather unstable hydrocarbons was necessarily conducted under the mildest possible conditions.

More stable alkylates were subsequently developed by substituting benzene for toluene, by using polypropylene instead of triisobutylene (thereby introducing the more stable secondary alkyl group), and by more closely fractionating the final product. These newer alkylates are easily and completely sulfonated to yield final sulfonate detergents of excellent color, odor and performance. They differ, however, from benzene in not being suited to partial pressure distillation procedures for completing sulfonation since they have high boiling ranges and in any case tend to darken and decompose above about 70 C, especially in the presence of sulfuric acid. On the other hand, these hydrocarbons do not easily form polysulfonates or sulfones, nor do they undergo serious decomposition when suitably treated with strong oleum, or even with sulfur trioxide provided it is applied in dilute gaseous form. Consequently, the use of such strong sulfonating agents is not only possible, but preferable, since it represents the only practical method for achieving complete sulfonation without the use of a large unproductive excess of acid. With sulfur trioxide the required quantity approaches theoretical.

With the choice of feasible sulfonating agents ranging widely from acid through oleum to gaseous sulfur trioxide, the preferred reagent will depend more upon practical than upon technical and chemical considerations. The most commonly used sulfonating agent is 20 per cent oleum. Manufacturing details for its use (including process steps, equipment and power requirements, and details for conversion to the sodium salt) have been published by several groups.[2, 9, 14] The same type of data for 22 per cent oleum is also available.[12] A typical process comprises gradual addition of 20 per cent oleum (1.25 lb per pound hydrocarbon) to the alkylate over a period of 1 to 1.5 hours with agitation and brine cooling to maintain the reaction temperature at about 25 to 35 C. After a digestion period of 2 to 3 hours at about the same temperature, water is added to assist layer separation, which requires 1 to 4 hours. The sulfonic acid layer is neutralized to yield a slurry, which upon drying has an active ingredient content of 85 to 88 per cent. The spent sulfuric acid layer (1.28 lb per pound alyklate) may be about 70 per cent in strength; it is discarded.

Detailed directions have also been published for the use of other sulfonating agents including sulfuric acid (98 and 100 per cent) and sulfur trioxide dissolved in liquid sulfur dioxide. One commercial process employs monohydrate acid followed by 20 per cent oleum to average 13 per cent oleum. Technical data and patents have appeared on the use of SO_3 vapor;[1, 4, 6, 10, 16] this is a new development coming into commercial operation in 1952 and has been made possible by the recent availability of stabilized liquid SO_3 and improved grades of alkylates. When employing the SO_3 vapor procedure, it is sometimes advantageous with certain alkylates to add a "heel" of sulfuric acid (5 to 15 per cent by weight of the hydrocarbon) to reduce the viscosity of the mixture during reaction and to improve the color of the final product. The sodium sulfonate produced with SO_3 has been found to differ from that made with 20 per cent oleum in that the former has a better odor and, when not using a heel, a higher active ingredient content (95 per cent as opposed to 85 to 88 per cent).

Oil-Soluble Petroleum Sulfonates. The drastic sulfonation of lubricant fractions to prepare mineral white oils has been operated industrially since about 1890. Three main steps are involved: (1) preparation of the base stock; (2) the sulfonation step proper, and (3) separation of the sulfonates from the sludge and the unreacted oil, which — after further treatment — becomes the desired white oil. The first step requires little comment, since standard lubricant refining procedures are employed. Refining by solvent extraction or by treatment with sulfuric acid is common practice.

Even though this type of process has been operated for nearly three-quarters of a century, published information on the sulfonation step is meager. Judging from available data, it appears that a typical procedure would be operated batchwise, and would involve the use of 20 per cent oleum (25 to 40 per cent of the weight of the oil) applied in three successive treatments ("dumps") with a 1- to 3-hour reaction time in the temperature range 40 to 70 C. The yields of oil layer sulfonate, expressed as grams per 100 grams original base stock, might be 5 to 10. This sulfonation has also been operated on a continuous basis.

Although 20 per cent oleum has been the usual sulfonating agent, sulfur trioxide has been used to some extent, especially since its introduction in commercially usable stabilized form in 1947. Advantages have been claimed for its use, namely improved yield of sulfonate, virtual elimination of spent acid, and formation of more concentrated sulfonate solutions. However, it has also been noted that the sludge formed when using SO_3 is more viscous than with the standard oleum procedure. This is to be expected, since the excess acid present with the latter procedure functions as a solvent and diluent for the sludge.

Although the actual manufacturing process for preparing these sulfonates is fairly simple, the chemical reactions occurring appear extremely complex. Mapstone[11] in reviewing the reactions that can occur during the sulfuric acid refining of gasoline, lists nearly a hundred possiblities, only five of which involve actual sulfonation or sulfation. As the acid treatment of gasoline is conducted under milder conditions than the oleum (or SO_3) treatment of the higher petroleum fractions for sulfonate and white oil manufacture, the latter is certainly more complex chemically.

It was recognized early that the sulfonates obtained in the white oil process could be broadly classified as oil-soluble ("mahogany acids"), comprising those remaining dissolved in the unsulfonated oil layer, and as water-soluble ("green acids") which were associated with the acid sludge. The former type is of much greater commercial interest than the latter.

The recent work of Sperling[15] represents the first really concerted attack on the chemistry of these petroleum sulfonates. They were separated into fractions by differential solubility and then hydrolytically desulfonated to the parent organic molecules, which were in turn separated into hydrocarbons and oxygenated compounds. The hydrocarbons were subjected to Waterman analysis for general determination of structure. In this way, the oil-soluble compounds were established as being entirely monosulfonated, while the water-soluble materials were shown to

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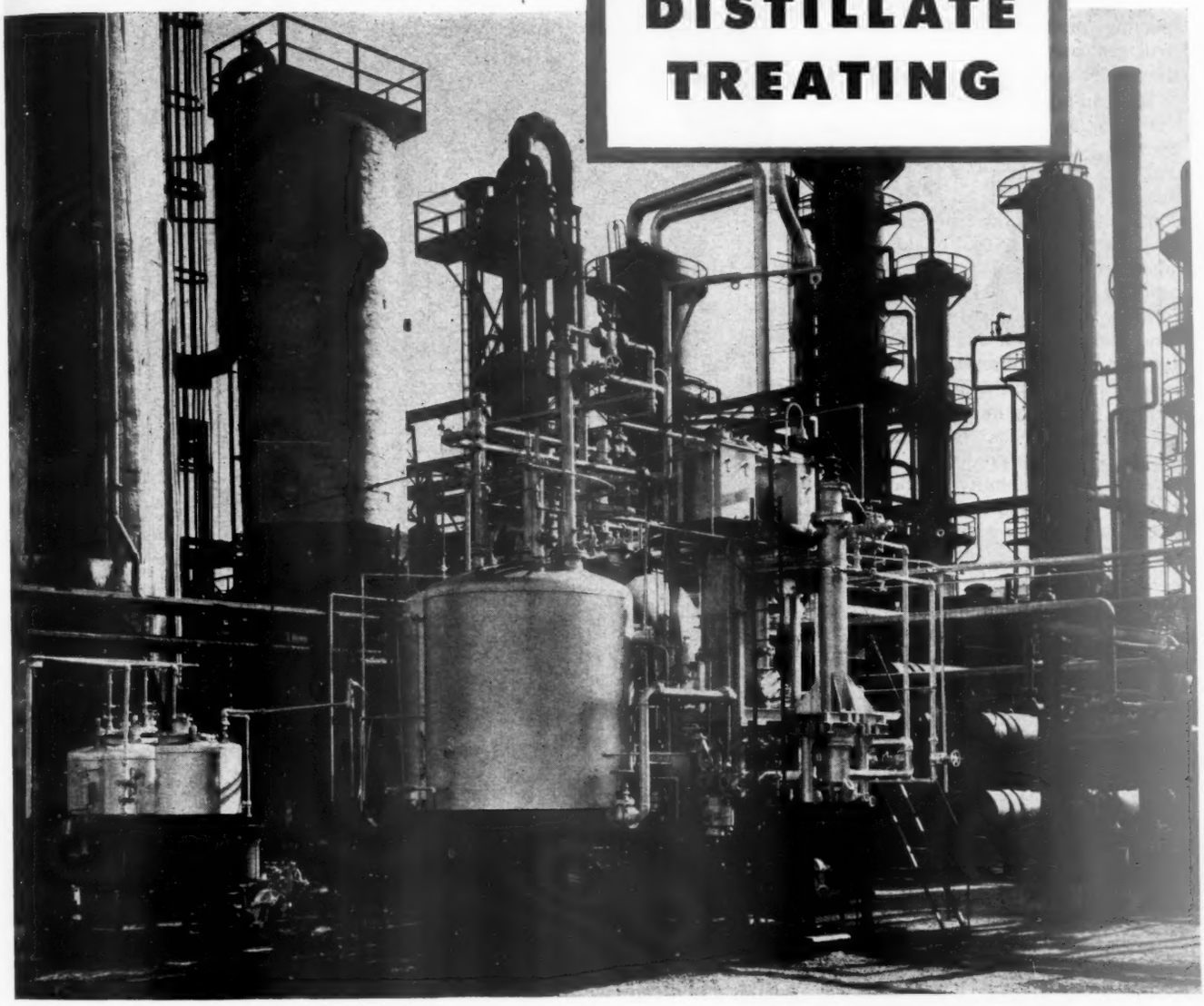

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be rich in disulfonated materials and oxygen compounds. The two types of sulfonates are strikingly different respecting method of formation, ring structure and degree of oxidation, as shown comparatively in Table 3.

The oil-layer sulfonates are thus characterized as being derived from hydrocarbons with small ring systems and long paraffin chains. They are therefore closely related chemically to dodecylbenzene, and would accordingly be expected to sulfonate with a minimum of oxidation using either 20 per cent oleum or SO_3 vapor, both of which are in fact used. On the other hand, disulfonation and extensive oxidation are often observed in the sulfonation of polynuclear aromatic hydrocarbons, and it is therefore not unexpected that the acid layer sulfonates were found to be predominately polynuclear. The instability of the hydrocarbons, recoverable from the acid layer sulfonates by desulfonation, is so great as to have warranted their semi-commercial exploitation for a time as synthetic drying oils.

The third step of sulfonate manufacture, comprising (1) isolation from the associated spent acid, sludge and unreacted oil, (2) purification (including decolorization and deodorization), and (3) methods of conversion to various metallic salts of commercial utility, has been the subject of constant study and many patents.

The oil layer sulfonates are in some cases not extracted from the unreacted hydrocarbon. Neutralization to the desired metallic salt is performed and the resulting oil solution is blended further as required to yield the desired formulation. If more highly concentrated sulfonates are required, the oil layer is extracted with alcoholic (e. g. ethanol, isopropanol) caustic soda. Distillation of the alcohol yields a mixture containing typically about 50 per cent oil and 40 per cent sulfonate. Further purification can be achieved by treating the alcoholic extract with petroleum ether; removal of the alcohol yields the substantially oil-free sodium sulfonate. Many modifications of these basic procedures have been patented involving the use of alternative solvents, but it seems doubtful whether many of these are used commercially.

The acid layer sulfonates are more difficult to recover since they are associated with sludge and spent acid, and comprise both mono- and disulfonates. They are furthermore of much less commercial interest than the oil layer sulfonates. Two general approaches have been employed for their recovery. One involves neutralization of the entire acid sludge layer, followed by "salting out" of the sulfonate in various possible ways. The second procedure comprises dilution of the sludge layer with about an equal weight of water leading to the formation of a bottom dilute acid layer containing disulfonates and a top layer of oil and sulfonates not soluble in the lower dilute acid layer. The top layer is neutralized and worked up by extraction procedures in a manner generally similar to that used for the oil layer sulfonates; the bottom dilute acid layer containing the disulfonates is discarded.

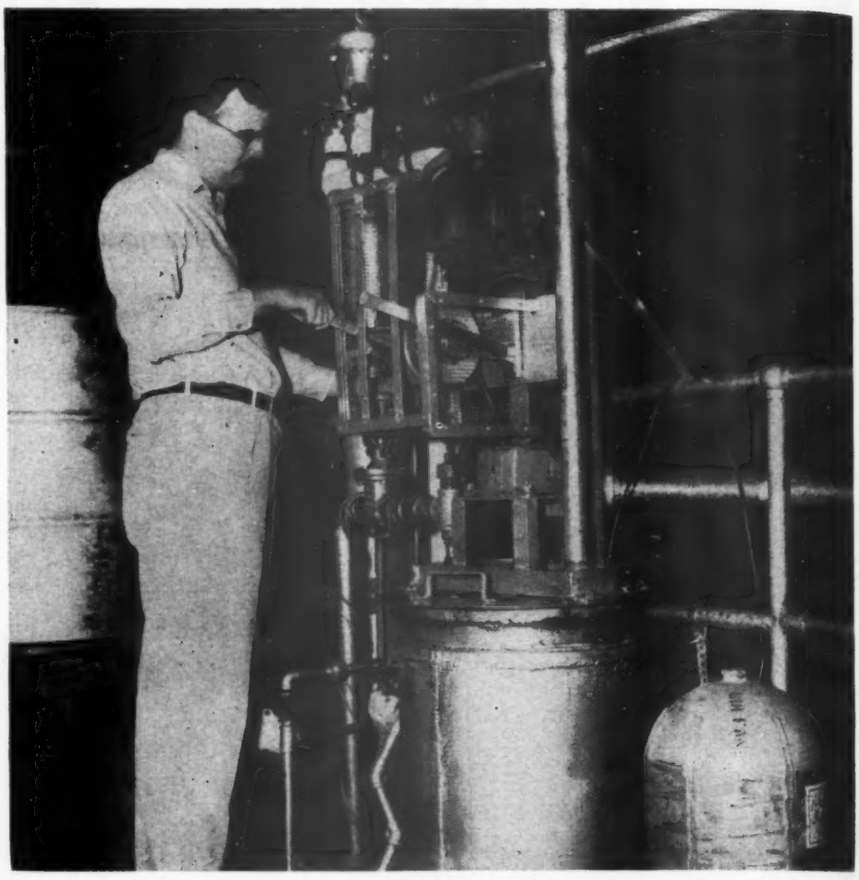

FIG. 3. Author Dr. E. E. Gilbert working with an experimental kettle in which sulfur trioxide is being used as the sulfonating agent.

TABLE 3. Comparison of "oil layer" and "acid layer" sulfonates.

	Oil layer	Acid layer
Hydrocarbon type	Long paraffin chains, small ring system	Short paraffin chains, rings polynuclear
Disulfonate content	Nil	About one-third
Composition of hydrolysate:		
Hydrocarbons	97.24%	44.5 to 67.8%
Oxidation products	2.76%	55.5 to 28.6%
Mean molecular wt. of hydrocarbon	341	232 to 297
Stability of hydrocarbon to oxidation and heat	Stable	Unstable
Method of formation	Direct aromatic sulfonation	Dehydrogenation of cycloparaffins, followed by sulfonation of the "cyclohexane type"; also some direct aromatic sulfonation.

The heavy demand for oil-soluble sulfonates has prompted the development of such based on the alkylation of benzene with paraffin wax. Another source for these materials involves the sulfonation (with 20 per cent oleum or with SO_3 vapor) of the high-boiling alkylated benzenes obtained as distillation residues in the manufacture of dodecylbenzene detergent alkylate.

Miscellaneous Sulfonates. Several hydrocarbon sulfonates of possible petroleum origin are of comparatively minor interest and will be discussed briefly.

The disulfonation of benzene has long been the basis of the only commercial process for manufacturing resorcinol. (In 1953, however, competition appeared in the form of the diisopropylbenzene oxidation process). The first sulfonic group is introduced as described under the monosulfonation of benzene for the production of phenol. The second group enters with difficulty and requires a large excess of oleum according to one process long in commercial use. Neutralization of the excess spent acid with lime yields 6.5 tons of calcium sulfate per ton of

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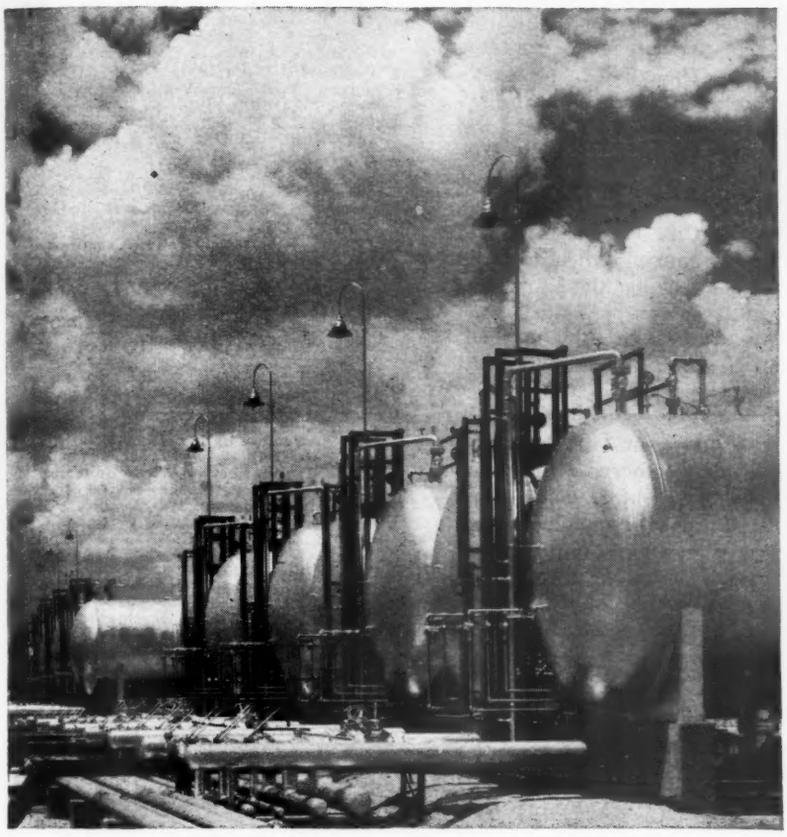

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resorcinol. This objectionable situation has prompted several studies of the use of SO_3 for introducing the second group, a procedure which theoretically would yield no spent acid. This approach has shown definite promise, since yields of disulfonate of 80 per cent or better are reported.

Volume production of toluene from petroleum, combined with shortages of cresols derived from coal tar, has stimulated interest in the sulfonation of toluene intermediate to the production of synthetic cresols. Toluene is somewhat more easily sulfonated than benzene, and its low boiling point (111 C) renders it well suited to the partial pressure distillation (Tyrer) technique for completing the reaction. The formation of three possible isomers is, however, a complicating factor. The Tyrer approach has been used industrially for preparing the mixed isomers, and sulfonation with excess monohydrate acid, followed by water dilution and crystallization, yields the para isomer as a solid of good purity.[7]

The mixed xylenes are even more abundantly available from petroleum than toluene, and they are even more easily sulfonated. Sodium xylene sulfonate in concentrated water solution is an interesting solubilizing or "hydrotroping" agent for difficultly soluble compounds, and it is marketed for this use. Their boiling points and good stability render the xylenes well suited to the partial pressure distillation approach. This procedure has been studied experimentally using xylene of petroleum origin starting with 98 per cent acid and operating in the temperature range 145 to 165 C.

Two types of sulfonated polystyrene are of interest — one completely insoluble in water and made from styrene-divinylbenzene copolymer, the other water-soluble and prepared from the homopolymer. The copolymer sulfonation is entirely heterogeneous—the hydrocarbon being reacted in bead form with excess concentrated acid at 100 C. Special conditions are required to achive smooth and uniform penetration of the acid into the beads with corresponding even removal of heat to avoid straining and cracking; the same percautions must be observed during the removal of excess acid after sulfonation.[18] The homopolymer is sulfonated in solution in an organic solvent with SO_3 also in solution or in complex form. By-product sulfone formation must be carefully avoided, otherwise the product will lack the required water solubility. The sulfonated copolymers may be regarded as strong, monofunctional acids in solid, insoluble form; they have a variety of promising uses as ion-exchange resins. The soluble sulfonated homopolymers, on the other hand, are of interest as thickening and sizing agents, tanning agents, and soil-conditioning compounds.

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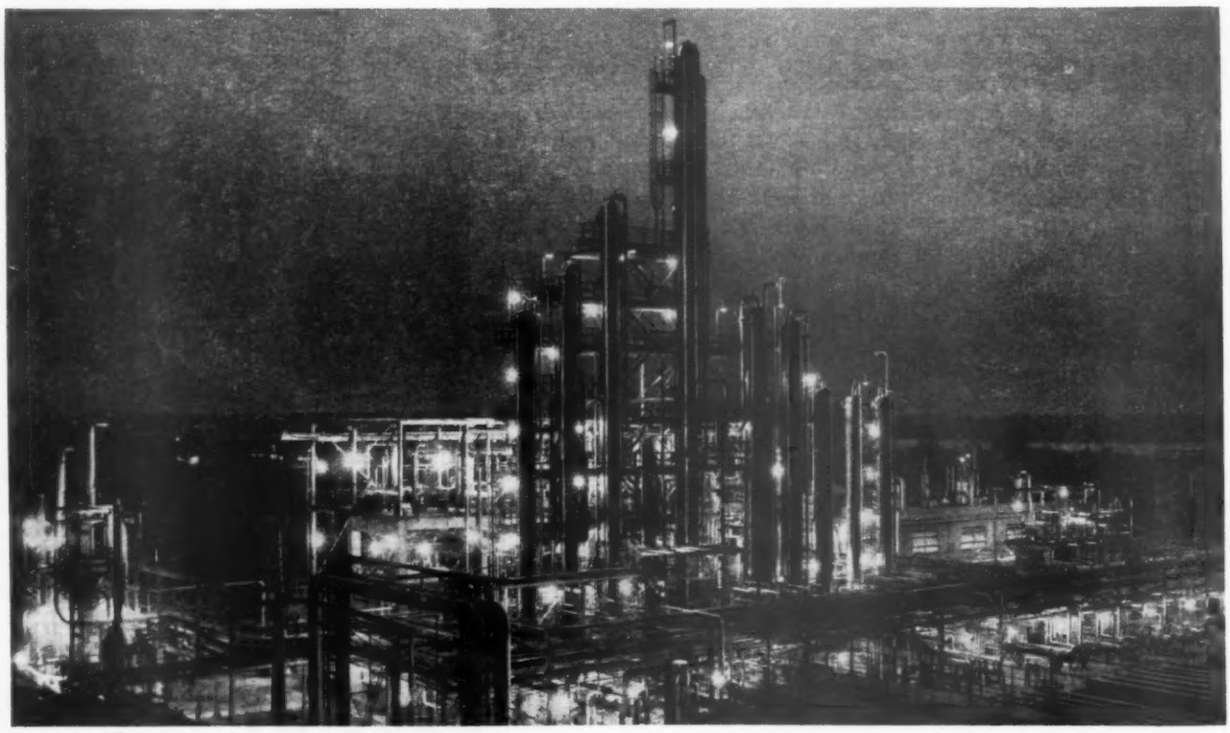

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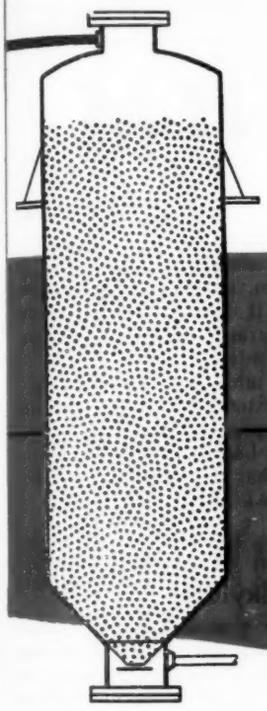

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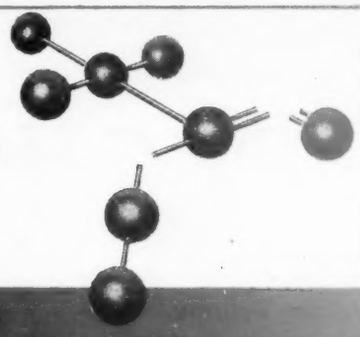

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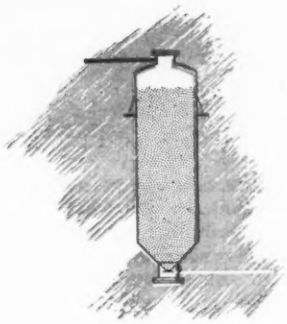

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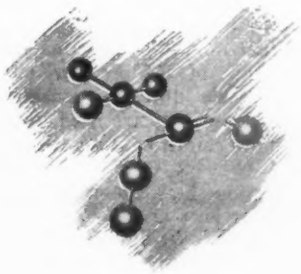

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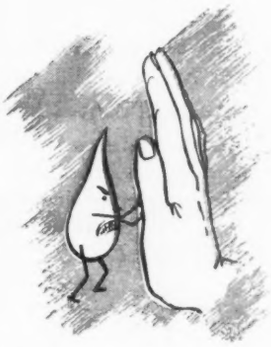

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Weight-Volume Conversion Factors

Q Why does the petroleum inspectors' manual and the engineers' handbook show a factor of approximately 8.329 for converting high specific gravities to pounds per gallon and a factor of approximately 8.321 for the conversion of low specific gravities to pounds per gallon? ***C .C .A.***

A The reason for the discrepancy in the figures cited for pounds per gallon at high and low API gravities is that different units used for recording the specific gravities are different from those for pounds per gallon.

All commercial weights in the United States are weights in air, and the units of weight such as pounds per gallon corresponding to °API, are given on this basis. The specific gravities reported in the formula

$$°\text{API} = \frac{141.5}{\text{Sp Gr } 60/60°\text{F}} = 131.5$$

and in the tables are based on densities in vacuo, that is, corrected for the buoyancy of air. The apparent weight of an oil is less in air than in vacuo. For purposes of conversion standard air is taken in the U. S. as 0.001217 gr per cubic centimeter (0.010 lb/gal) at 60 F, 760 mm pressure and at a relative humidity of 50 per cent. It is usually assumed that weighings were made with brass weights of 8.4 gr per cu cm density. Slightly different densities of air and brass weights are used in Great Britain and in countries using the metric system.

The relation between weighings in vacuo and air is:

Wt in Vacuo = Wt in air + (wt of volume of air displaced by oil — wt of volume of air displaced by weights)

or

$$W_V = W_A + \rho_{air}\left(\frac{W_A}{\rho} - \frac{W_A}{8.4}\right)$$

where

W_V = wt of oil in vacuum
W_A = wt of oil in air
ρ_{air} = density of air
ρ = density of oil
8.4 = density of brass, gm/cu cm

if measurements are made at standard conditions

$$W_V = W_A\frac{0.001217}{\rho} - 0.000145 + W_A$$

or

$$W_V = W_{A(1+K)} \text{ where } K = \frac{0.001217}{\rho} - 0.000145$$

To compute specific gravities relative to water at 60 F densities of water are: 0.9990 gm per cu cm in vacuo and 0.9978 gm per cu cm in air.

The correction for brass weights is used in correcting measured densities.

Table 1 gives the calculated densities and specific gravities in air and in vacuo for a few values of API. The pounds per gallon in air and specific gravities in vacuo were taken from the American Edition of the ASTM-IP. Petroleum Measurement Tables, ASTM D-1250 1952. When the pounds per gallon in air is divided by the specific gravity in air, there is a negligible variation in the quotient over the range of °API used.

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Q What factor (60 F) should be used for calculating the pounds per gallon from measured specific gravity of petroleum residues heavier than 0 API? ***C. C. A.***

A The method used to compute the pounds per gallon for degrees API less than O from measured specific gravities depends upon the method of measurement. If an accurate hydrometer is used, it should be properly calibrated; in this case it would be preferable to use specific gravities in vacuo. If Westphal balances or pycnometers are used and accurate results desired corrections must be made for the volume of weights and of the plummet or pycnometer. It is merely, then, a matter of estimation of the density if the air surrounding the weighing apparatus, and of computing either one standard specific gravity or the other. A table similar to Table 1 (but more extensive), which relates densities and specific gravities to pounds per gallon can be prepared. It should be remembered that the pounds per gallon weighed in air is the required value.

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Conversion of selected data from ASTM D-1250 tables to corresponding values in vacuum and in air.

	From ASTM-IP tables			In Vacuo		In air — with brass weights		
API	Lb/gal (in air)	Sp gr (in vac)	Lb/gal(air) / sp gr(vac)	Lb/gal	Density gms/cc	Density gms/cc	Sp gr	Lb/gal / sp gr
0	8.962	1.0760	8.329	8.970	1.0749	1.0738	1.0760	8.329
10	8.328	1.0000	8.328	8.337	0.9990	0.9979	1.0000	8.328
20	7.778	0.9340	8.3276	7.787	0.9331	0.9320	0.9339	8.329
30	7.296	0.8762	8.3269	7.305	0.8753	0.8742	0.8760	8.329
40	6.870	0.8251	8.3260	6.878	0.8242	0.8231	0.8248	8.329
50	6.491	0.7796	8.3261	6.499	0.7788	0.7777	0.7793	8.329
60	6.151	0.7389	8.3245	6.161	0.7382	0.7371	0.7386	8.328
70	5.845	0.7022	8.3238	5.854	0.7015	0.7004	0.7018	8.329
80	5.569	0.6690	8.3244	5.577	0.6683	0.6672	0.6686	8.329
90	5.317	0.6388	8.3234	5.326	0.6382	0.6371	0.6384	8.330
100	5.087	0.6112	8.3230	5.096	0.6106	0.6095	0.6108	8.328

Comparison of H_2SO_4 and HF Alkylates

Q From a practical plant production viewpoint, what differences in composition, if any, are found in the products of alkylation via (1) sulfuric acid catalyst; (2) hydrofluoric acid catalyst, (3) by high pressure hydrogenation of codimer? ***M.L.E.***

A It would be fairly easy to give a simple answer to this question by setting forth the compositions of typical alkylates and polymer gasolines, but from a production viewpoint, yields, investment and available hydrocarbon gases need to be considered. Comparing first the two alkylation catalysts, sulfluric acid and hydrofluoric acid, the choice might hinge on the availability of a sulfuric acid recovery plant. Then there is the question of flexibility to meet changing requirements. Hydro-codimer might be made where an adequate supply of butylenes is available with no excess of butanes.

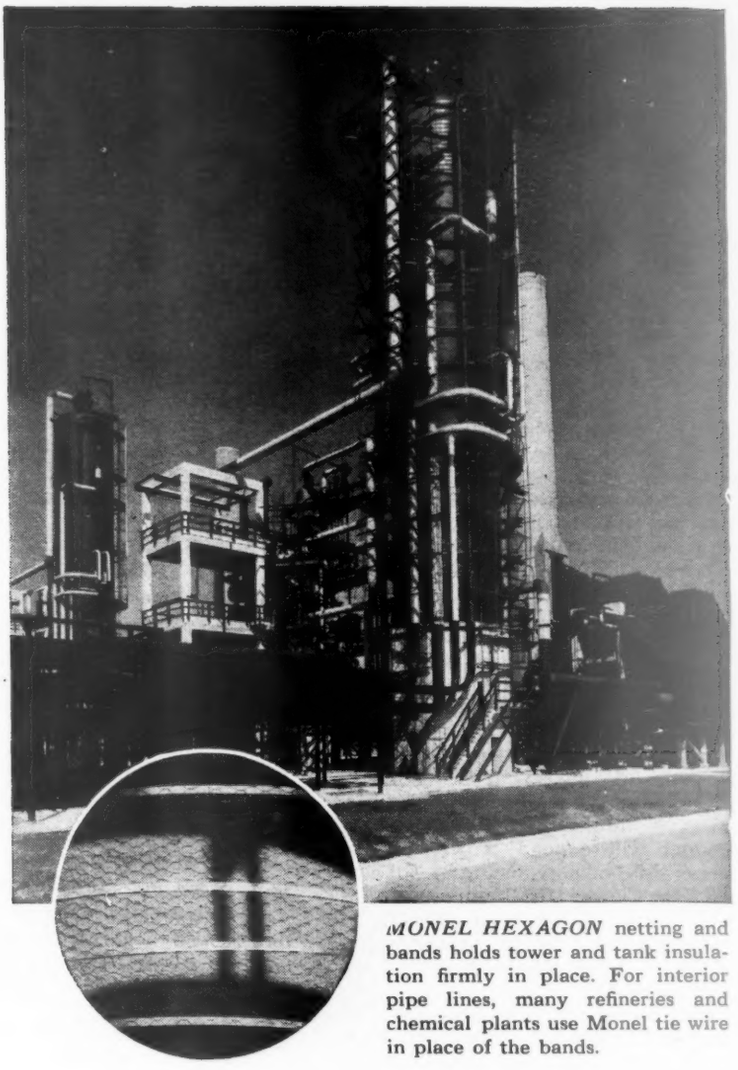
Probably the chief difference between sulfuric acid alkylate and HF alkylate is that the latter contains about twice the amount of 2, 2, 4-trimethyl pentane, increasing with the octane number of the alkylate.[1]

The following analyses of depentanized alkylate from mixed butylenes were determined in API Project 6.[2]

	H_2SO_4	HF
Hexanes	6.8 vol,%	2.1
Heptanes	7.0	4.5
2,2,4 Trimethyl pentane	26.7	41.7
2,2,3 Trimethyl pentane	1.3	21.9
2,3,3 trimethly pentane	13.5	10.0
2,3,4 trimethyl pentane	14.3	9.4
Dimethyl hexanes	11.2	19.6
Nonanes	6.4	3.4
Heavier	12.8	6.4

As 2, 2, 4 trimethyl pentane is isooctane, and therefore has an octane number of 100, it serves to enhance the octane blending value of the HF alkylate, although, in general, both alkylates have about the same octane blending value, varying somewhat with feed stock and operating conditions. For example, HF better utilizes propylene in the feed stock. In either case,

How to Insulate Your Towers against rising maintenance costs



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a high content of isobutane is necessary in alkylation.

HF alkylate requires treatment to remove alkyl fluorides, which is usually done by filtration through bauxite, followed by alkali wash.[3] Treatment with dehydro-fluorination catalyst also can be used.[4] Although HF used in alkylation must of necessity, be recovered because of cost and toxicity, losses amount to about one-half pound per barrel of akylate or less.

Polymerization—Polymerization of C_3-C_4 olefine at 300-350 F and 900 psig gives a selective polymer in which octenes predominate. On hydrogenation, this polymer has an octane number of 90-96.[5] Advantages in temperature control result from use of a tubular reactor instead of a chamber for the phosphoric acid-silica catalyst. A stabilizer gas stream containing about 12-15 propylene and 20-25 butylenes is suitable. At 375-475 F, non selective polymerization gives a polymer containing most of the propylene as well as the butylenes. This is called a "conjunct" polymer by Ipatieff & Pines[6] in contrast to the true polymers such as dimers, trimers, etc. From a mixed olefin feed, the lower temperature produces mainly isobutlylene dimer and trimer, while the so-called "codimer" results from higher operating temperatures. Naturally, the character of the product will depend largely on the temperature of polymerization. In general, the lower the temperature of polymerization, the more selective is the polymerization of butenes, isobutene yielding products which on subsequent hydrogenation are largely branched chain octanes and, most selectively, iso-octane. These polymer gasolines are especially suited for use in aviation fuel because of their relatively low vapor pressure and high octane number. When used as blending stock in motor gasoline, they permit use of larger amounts of casing head gasoline without exceeding vapor pressure specifications.

Non-selective polymerization described by Egloff and Welnert[5] carried out at 400 F over phosphoric acid-silica catalyst gave a gasoline of 130-150 bromine number 10.9 Reid Vapor Pressure and 66.6 API gravity with the following distillation:

	°F
Initial, per cent	90
10	146
30	202
50	228
70	264
90	330
End point	400

The knock rating was:

ASTM — Clear —	82.5
ASTM — + 3cc TEL	85.0
Research method — Clear	97.0
Research method — +. 3cc TEL	100.0

The reaction pressure also influences to some extent, the composition of the polymer. Thus in the case of propylene over phosphoric acid-silica catalyst at 205 C, increase in pressure from 250 psig to 1800 psig, markedly increased the formation of dimer.[8]

In an economic comparison of alkylation and polymerization, Sutherland and Doegey[7] gave the following product knock ratings:

	Polymer gasoline	Alkylate
F2 — clear	82.5 — 83	91+
F2 + 3cc TEL	84 — 84.5	98+
F1 — clear	96 — 97	92 — 93
F1 + 3cc TEL	99 — 100	98+

Summarizing the foregoing, there is little difference from the standpoint of producing gasoline in the plant by blending, between alkylates resulting from sulfuric acid and hydrofluoric acid. Hydrogenated butylene codimer, having a narrower boiling range, coupled with a higher octane number, would be better adapted for aviation gasoline. Higher potential production of alkylates where excess butanes are available usually make the alkylates more attractive from the economic standpoint.

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—*Vanderveer Voorhees.*

HF Alkylation

Q What are the respective interrelationships between concentration of acid, acid- oil charge ratio, and olefin-isoparaffin ratio, in HF alkylation? *J. N. C.*

A In HF alkylation it is essential to have a high ratio of olefin to isoparaffin to avoid excessive polymerization of olefin and other side reactions. Bolles[1] recommends a ratio of 6:1 for aviation alkylate and 3:1 for motor alkylate. Penick[2] gives a preferred range of 6:1 to 10:1 isobutane to olefin. The optimum ratio for any given installation will be determined from an economic balance between the increased value of the alkylate resulting from a high ratio and the additional cost of recycling isoparaffin.

The rate of HF to hydrocarbon charge should be sufficiently high to exceed the solubility and provide a separate liquid phase. More acid than this does no harm and has no particular advantage beyond improving contact, where the degree of agitation is not as high as desired. An excess of 100 per cent above the amount required to saturate can be used[3] with no penalty other than the cost of recovery. A ratio of 1 volume of Liquid HF to from 1 to 2 volumes of hydrocarbon feed is usual practice. There is nothing to indicate that there is any essential relation between acid:hydrocarbon ratio and isoparaffin:olefin ratio, but where the latter is high, it would be expected that the amount of excess acid could be reduced with some saving in cost of recovery.

From 10 to 15 per cent of water can be present in the HF, but more than this seriously affects the rate of alkylation. Although anhydrous acid can be used, there appears to be little advantage over acid of about 90 per cent titratable acidity. Possibly the higher concentrations of HF will be advantageous when using propylene instead of butylene as the olefin. Thus in alkylating benzene with a mixture of ethylene and propylene, Passino[4] obtained 96.2 per cent theory yield of propyl benzene using anhydrous HF. All the ethylene was recovered.

—*Vanderveer Voorhees.*

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Ethylene Glycol Synthesis

Q What are the essential reactions for the production of ethylene glycol from ethane, propane, etc. What are the major steps for this synthesis as carried out in commercial plants? *L. D. G.*

A The first step involved is, of course, the production of a relatively pure ethylene from the paraffin hydrocarbons mentioned. This is customarily done in a tubular cracking coil, operating at temperatures in excess of 1400 F, usually with a considerable proportion of steam in the coil to hold down carbon formation. Ethylene is separated by precision fractionation, unconverted ethane or propane being returned to the cracking coil. The ethylene produced is better than 95 mol per cent ethylene, balance being for the most part ethane and methane. Acetylene must be low.

There are two processes in commercial use for producing ethylene glycol from ethylene. The older process involves the reaction of ethylene with hypochlorous acid to form ethylene chlorhydrin, and then hydrolysis of the chlorhydrin with a mild alkali such as sodium bicarbonate. Much of the glycol of commerce is produced by hydration of ethylene oxide, which can be effected by heating the oxide under pressure with water with or without a mild catalyst.

The newer process involves the oxidation of ethylene with air or oxygen to produce ethylene oxide, followed by hydration of the oxide to glycol as mentioned above. Several of the new plants built or under construction within the last two years employ this process. When ethylene oxide is thus hydrated a certain amount of diethylene glycol, triethylene glycol, and higher glycols are produced at the same time. These must be separated from the monoethylene glycol, where the latter is desired in pure form. For use as an antifreeze liquid it is usually unnecessary to remove them. Removal is effected by distillation. *C. R. Wagner.*

L. U. Garrett, G. S. Cradduck, and Claude Gray, all of Skelly Oil, "talk it over" at NGAA meeting in Amarillo, Texas, November 20, 1953.

Natural Gasoline Association Meeting

Freedom Must Be Sold to Be Retained

ARCH L. FOSTER*

"THE survival of our system of free enterprise depends largely on how well you sell it to others."

Thus spoke Stanley Learned, executive committee chairman and assistant to Phillips Petroleum Company's president, to the Natural Gasoline Association of America in Amarillo on November 20, as he outlined the "far-flung battle line" of the Free World facing totalitarianism and collectivism. He summed up the part that oil and gas industries must play to maintain the freedom that has brought the world's greatest economic, political, sociological, and scientific development known to man. The great single foe of industry today is totalitarian statism; the issue, collectivism or state control as against the individual initiative principle known as free enterprise.

Commenting on the three-phase promise of Abe Lincoln at Gettysburg, the speaker pointed out that "Government *of* the people is the people's necessity," quoting recent publicized statements, "Government *for* the people is the people's privilege, and government *by* the people is the people's responsibility." It is this responsibility that makes it imperative to sell the advantages of free enterprise and individual initiative, over any other system in the world.

If we do not sell these advantages we stand a good chance of losing this liberty, this freedom that a large part of our population has supinely taken for granted. Our material welfare is the product of three factors, natural resources, tools, and human energy. The great variable in this equation is the quantity and quality of human energy available in the people. That energy discovers and develops natural resources, carries on the work of refitting these resources to the use and service of mankind; that energy develops, invents, improves, and applies tools to these ends, this is the theme-song of the speaker's appeal.

Only where the spirit of man is free will he produce effectively, Learned said. And by direct implication the throttling of governmental controls substitutes "police power enterprise" for the better "free enterprise." The idea is crystallized in Woodrow Wilson's famous statement, "A concentration of governmental power always precedes the death of personal freedom." Our system of free enterprise is not infallible, but provides the greatest economic good for the greatest number (of people), preserves human dignity from political and economic tyranny and is the best system for that purpose yet devised, Learned affirmed.

And our best and bounden duty, it was included, is to sell those facts to all the people; we must sell this system over and over, that free enterprise is the servant of all the remainder of our liberties, giving the greatest economic good to the greatest number of people in an atmosphere of freedom never before equalled in the world. This is not easy; collectivism appeals to man's baser instincts, slothfulness to escape personal responsibility; the sadistic instinct to destroy those better than he; the venal instinct to want something for nothing; the cowardly, to condone or excuse evil-doing through mob action, and (worst) to the pagan instinct by denying moral responsibility to the Creator. Free enterprise must sell the desirable side of these items, but can show as reward the greatest civilization known yet to man.

Natural Gas Use Greater, Price Higher

Complications of value and consumption rate for natural gas are introducing more problems for the natural

*Refining and Petrochemical Editor.

EXCLUSIVE

gas producer, processor, and consumer, stated M. F. Schaffer of Witco Chemical Company. The rapidly expanding petrochemical industry, with its large hydrocarbon consumption, is at least one solution to the economic ills of the gas business, he observes. With increased consumption of dry (stripped) natural gas, less of it is flared or reinjected into producing formation, and therefore the value of the gas is that of a salable commodity, not merely a nuisance value. Earlier, long-term contracts were made for purchase of gas. Gasoline plants charged for dehydration, compression and stripping—hydrocarbon recovery—for gas returned to the seller or to a purchaser; now, gasoline plants are employing higher pressures to increase amount and efficiency of recovery. Markets for LPG and for more natural gas line have enabled the plant operator to sell more products from the raw gas at a higher price than natural gas fuel prices. Demand for various hydrocarbons for petrochemical raw materials; use of special products, such as isoparaffins for alkylation, etc., place a premium on recovered hydrocarbons. Dwindling of gas production in older areas has placed a premium on the remaining gas that has raised the cost to consumer. Increase in liquid hydrocarbon recovery —trebled in Texas between 1940 and 1949—had the double effect of reducing the market price of the recovered materials by supplying greater quantities for the existing market, and by making the gas correspondingly more valuable to the processor and thus to the seller-producer.

In some areas in Texas, where gas supply has been dwindling, well-head gas prices have increased to a range of from 8 cents to 15 cents, as compared to 4 to 6 cents in 1945. Just after the war investors and promoters learned the value of natural gas, which resulted in a wild scramble to buy reserves, Schaffer pointed out. In addition to all these problems that increase gas prices and costs, others include increasing tax rates, wages, materials costs and lowered prices for hydrocarbon products recovered.

Development of new products, or new uses for old products will probably be the key to survival of the natural gasoline plant. Thus Speaker Schaffer outlined the procedure by which the natural gasoline industry may live under the changing conditions of tomorrow.

Measuring Gas by Orifice Meter

Definite specifications have been set up by the American Gas Association controlling "the orifice plate and meter run to permit duplication of the basic elements from which orifice coefficients were determined," as outlined by W. R. Kehoe of American Meter Company. Kehoe summarized the conditions that may arise to change these conditions, during use of the meter, conditions that may cause error, and thus that must be guarded against. Some of these are:

Upstream edges of the orifice may become rounded by abrasion, causing low differential and thus low measurement. Dirt on the upstream side may have effect of a rounding of this edge.

Dirt in the meter run ahead of the orifice plate may cause either high or low measurement, depending on the amount of the buildup.

Any change in the inside surface finish of the meter run may change the measurement; extra roughening beyond that of standard pipe generally causes low differential and thus low measurement. The means for guarding against these sources of error is to inspect run and plate periodically to insure against unpermissible deviations from standard conditions. Measurement and flowing conditions will dictate how often these inspections should be carried out.

Other factors that influence accuracy are:

Improper chart notations such as failing to enter new factors on the chart when an orifice is changed.

Pits in orifice plate eventually will lead to trouble.

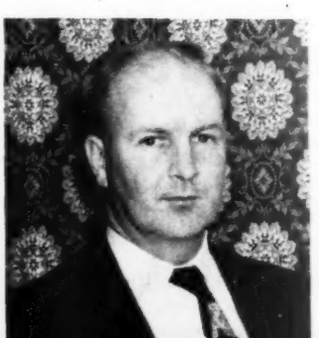
Small nicks at one point in the orifice have much less effect than when the entire circumference of the orifice develops "radius" on the upstream side.

Burrs protruding into the line from taps should be guarded against, since they may cause serious errors.

All these items sum up to the matter of keeping the meter parts in first-class repair; variations from accuracy can be determined best by calibration tests, Kehoe pointed out.

Important and practical details of the choice and operation of gas dehydrating methods were presented by John Campbell of Black, Sivalls and Bryson, Inc., details that we hope to publish later. In this paper Campbell discussed ways and means of regenerating desiccants, such as aluminum trihydrate, silica gel, etc., via hot propane, and subsequent separation of propane from the water by after condensation and return of propane to the system. Multiple towers have advantages, he said; use of a coalescer to collect very small droplets and thus drop them out of the stream has shown advantages, also. *

Stanley Learned
Phillips Petroleum Company
was principal speaker.



W. H. Kehoe
American Meter Company

John A. Craig
Skelly Oil Company
presided over one session.

John Campbell
Black, Sivalls and Bryson, Inc.

Fuel Oil Upgraded to Diesel by Additive

Ignition-improving amyl nitrate mixture converts low cetane stocks to premium quality product

EUGENE B. BRIEN*

A NEWLY-DEVELOPED ignition improver for diesel fuels, designed to help refiners produce the desired grades of diesel fuel simply and economically, is now being marketed by the Ethyl Corporation.

The chemical additive, a mixture of primary amyl nitrates, is reported as capable of transforming conventional heating oils into diesel fuel of acceptable quality and of simplifying the refiner's and jobber's task of storing and meeting the relative demands for both products. Easy to blend with middle distillates, the additive should make refinery operations much more flexible, the company states.

As little as 1/10 per cent by volume of the new ignition improver is said to raise many distillate heating oils to within the cetane range of commercial diesel fuels regardless of crude source, refining technique or sulfur content. (Fig. 1.)

With a synthetic cetane rating of about 250, the additive serves to promote the efficient combustion of fuel in the diesel engine by shortening the ignition delay period, that is, the time-lag between the start of injection and beginning of combustion.

The product is the result of five years of research and development work by Ethyl's research laboratories. The mixture of primary amyl nitrates ($C_5H_{11}NO_3$) emerged as the best, from a cost-effectiveness standpoint, of some 300 compounds investigated. Tests indicate that the cetane numbers gained with the amyl nitrate additives are equal to natural cetane numbers in practically all respects. The compound is manufactured by a company developed and patented process.

*Eastern Editor.

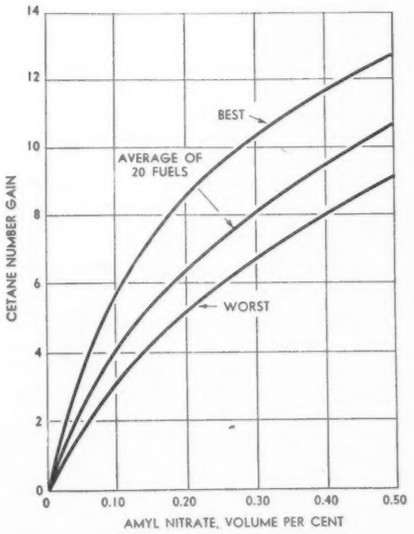


FIG. 1. EFFECTIVENESS of amyl nitrate as shown in tests with 20 representative diesel fuels.

EXCLUSIVE

Spiraling Demand Presses Refiners

Spectacularly expanding demand for diesel fuels in the past 12 years has changed the production pattern for the middle boiling fractions of crude. Between 1941 and 1951, demand for diesel fuel increased four-fold, and last year it increased another 14 per cent over 1951 — to 6.1 billion gallons. (During the same time, demand for gasoline increased less than 2/3.) By the end of the current decade, responsible estimates place consumption at an impressive total of 9 billion gallons.

Paced by the rapid dieselization of their lines — since 1949, 98.7 per cent of new locomotives has been diesel powered — the railroads last year bought 2.7 billion gallons of fuel, a 16.6 per cent increase over 1951. In 1952, the railroads bought six times as much diesel fuel as in 1946. By 1960, when most railroads will have completed their dieselization, it is expected they will consume about 4.4 billion gallons, nearly half of the projected national consumption. (Fig. 2.)

Meanwhile, demand for burner oils

FIG. 2. SINCE 1949, over 98 per cent of new locomotives have been diesel powered.

FIG. 3. FOUR-CYLINDER, two-cycle diesel engine can haul loads of 55,000 lb. Diesel is being tested on proving ground.

FIG. 4. THREE-CYLINDER diesel excavates 42-in. trench 13 ft deep at a rate of 350 ft in an 8-hour day.

between 1946 and 1952 almost doubled in home and industrial use; demand for jet fuels and catalytic cracking stocks for high octane gasoline also showed heavy increases.

As fractions in the middle boiling range are fairly constant in a typical barrel of oil, the spiraling competitive demand for these fractions is creating increasing difficulty in refining operations and available base stocks.

Cetane Numbers

Considering diesel fuel alone, the importance of cetane number to proper engine operation may be clarified when one understands how cetane numbers are measured. Diesel oil is rated by cetane numbers on a scale analogous to the octane scale for gasoline. The primary reference fuels used are cetane — with an assigned value of 100 — and alphamethylnaphthalene — with a value of O. Blends of these two hydrocarbons represent intermediate ignition qualities and their assigned cetane number is the percentage of cetane in the blend. Thus, a reference fuel blend containing 45 per cent cetane and 55 per cent alphamethylnaphthalene is assigned a cetane number of 45. Tests for cetane number determination are conducted in a standard ASTM, single cylinder cetane engine. By selecting a reference fuel mixture of known cetane rating that produces the same ignition delay as a test sample, the cetane number of the test sample is established.

The ignition delay period is the interval of time, measured in milliseconds, between the injection of the fuel into the cylinder and the start of combustion. The higher the cetane number of the fuel, the shorter the ignition delay in the cylinder and the better the ignition quality of the fuel. The lower the cetane number, the longer the delay before ignition. When the ignition delay is excessively long, the fuel burns unevenly and incompletely, causing smoke, loss of power, increased operating noise, and higher maintenance costs.

Base Stocks and Refinery Processes

To meet the increasing demand for quality diesel fuels, refiners have had to use a wide range of base stocks for diesel fuel production. The stocks preferred because of their natural high cetane rating are paraffinic and mixed paraffinic-naphthenic crudes. As the demand for diesel fuel surpassed the available supply of such stocks, refiners have supplemented the latter with other crudes of less desirable ignition characteristics.

At the same time, they have had to increase the yield of distillate fuels at the expense of residual yields. This is accomplished generally through the increased use of catalytic cracking, whose end products are essentially gasoline and distillate fuel, as compared to gasoline and residual fuel from thermal cracking.

Catalytic cracking produces oil fractions that are low in paraffins and high in aromatic hydrocarbons. Aromatics, however, are low on the cetane scale, so that cracked distillates have poor ignition quality. Cracked distillates, in fact, will generally run 5 to 15 cetane numbers lower than straightrun distillates from the same crude source.

FIG. 5. NAVAL diesel engines are assembled at the Cleveland diesel engine division of General Motors.

A considerable portion of cracked material normally can be blended with straightrun distillates of high cetane number to meet diesel fuel specification. But straightrun distillates from non-paraffinic crudes, or catalytically cracked distillates high in aromatics, present a cetane number problem.

Operational problems also may occur with some diesel fuel made from cracked distillates, unless properly stabilized by refinery treatment and/or the use of additives. Precipitates, caused probably by the oxidation of certain reactive sulfur and nitrogen compounds which then act as catalysts accelerating the oxidation of certain aromatic hydrocarbons, may form.

Some types of fuel raise the problem of incompatibility. Although stable alone, two fuels may become unstable when blended together, a condition generally attributed to the lower solubility of the blend and resulting in the precipitation of relatively insoluble materials. By clogging filters in operating engine, insoluble residues can stop it from functioning (Fig. 3.)

Practical Implications of the Additive

Many present difficulties of refining and marketing different grades of diesel fuel could be eliminated with the general use of additives such as amyl nitrate.

Probably the most important economic saving the company foresees is the elimination of dual storage facilities for marketers whose stocks are suitable for diesel fuel except for poor ignition quality. One grade of oil suitable for heating can then be stored and upgraded to quality diesel fuel by the addition of amyl nitrate. Cetane rating is reportedly raised as high as 10 numbers with the additive. Marketers who rely on pipeline distribution from refinery to bulk station would find this of particular value, it is said.

With amyl nitrate, refiners may expect more flexible operations in the future. They can, says the manufacturer, either eliminate or reduce the selective blending now required in many localities to produce high quality diesel fuel. At the same time, refiners can blend unfinished stocks for the desired pour point and volatility and obtain the required cetane level with amyl nitrate. This would be particularly valuable in fuels intended for Arctic use. At present, such fuels must have a -40 to -70 F maximum pour point, according to Military specifications. But presently available fuel types of the desired low pour point are relatively low in cetane with the result that Military specifications for Artic fuel presently carry only a 35 minimum cetane specification. Refiners may also be able to increase their production of diesel fuel by including greater quantities of cracked and straightrun distillates of low cetane number. By adding amyl nitrate to these poorer blends, they could still meet cetane specifications.

When the additive is used widely it is claimed that operators of diesel

another 1st

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engine equipment may expect to have generally available throughout the nation a more uniform type of diesel fuel of high ignition quality, much as high octane gasoline is now readily available in all areas. This situation should minimize the operational problems arising from the wide variety of diesel fuels now marketed. (Fig. 4.)

Additive Mixes Readily

Mixing the additive in heating oils is reportedly a simple pouring process that requires no special equipment. As an experiment, the manufacturer pumped a quantity of No. 2 heating oil and poured the required amounts of the ignition improver directly into the holds of several tank trucks and a railroad tank car. The turbulence caused by the filling operation and the motion of transportation afforded complete mixing.

Separation of the additive from the diesel oil in storage is not a problem. All sections of the railroad tank car, for example, showed the same concentration of the additive over a period of many days.

Navy Accepts Additive

Up until 1952, the U.S. Navy Bureau of Ships specified a diesel fuel made from a straightrun product with a minimum natural cetane number of 50. Because of the increasing civilian demands for middle distillates in heating oils, jet fuels, and charge stocks for catalytic cracking and the resulting possibility of a shortage of 50 cetane straightrun to meet wartime requirements, the Navy began large scale service tests in 1951 with Ethyl's ignition improver. (Fig. 5.)

The test program was conducted in a squadron of submarines using Venezuelan straightrun fuel of 46.5 cetane number. By adding 0.18 per cent by volume of amyl nitrate to each gallon of fuel, the average cetane number of the fuel was satisfactorily raised to 53.5. The Navy also wanted its additive to retain its ignition quality in storage, to have no objectionable engine operations (smoke, noise, odor), to present no health hazard, and to produce no adverse effects on engine cleanliness, wear and operation.

Test Results Approved

Tests were concluded satisfactorily on all counts, according to its reports. As a result, in 1952 the Navy revised its specifications for Class 1 diesel fuel to permit the use of the ignition improver, the first time any such additive has been permitted.

The Bureau of Ships now reports that, as a result of this change, its potential supply points for Class 1 diesel fuel of 50 cetane have been greatly multiplied in case of disruption of oil transport facilities in war. The same applies to Arctic fuels of 35 minimum cetane number and -40 F maximum pour point. The use of amyl nitrate, it says, should prove of great benefit in providing fuels of the desired characteristics for Naval cold weather operations. (Fig. 6.)

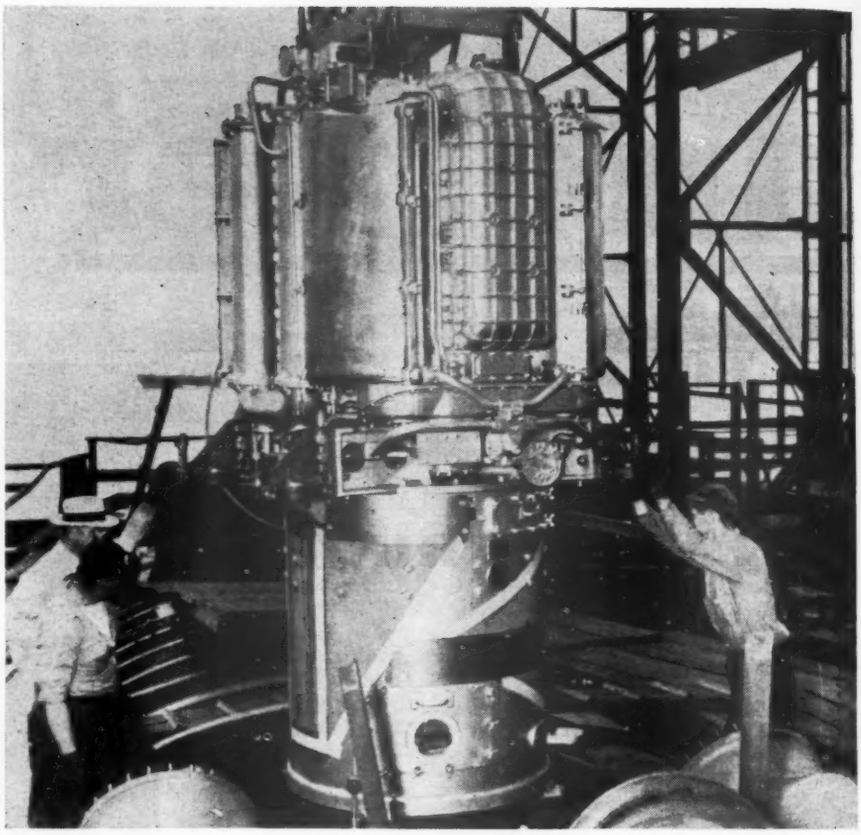

FIG. 6. LATEST and most compact submarine engine being lowered in U.S.N. submarine TROUT has ⅓ weight of previous models.

Marketing Acceptance

Now used in diesel fuel for trucks, stationary engines, tractors, etc., by seven marketers on the East and West Coasts, the Mid-West, and Canada, the additive is reported as well received. Prior to its sale, the manufacturer conducted extensive performance tests, including six 50,000-mile tests in diesel trucks operating under widely varying conditions.

One firm* reported it found the ignition improver of particular value in meeting the specialized demand for premium diesel fuel in widely scattered areas throughout the West. It has been able to upgrade conventional stove oil (No. 1 heating oil) of 39 cetane number to a premium grade diesel fuel of 46 cetane number. The No. 1 heating oil available in the West happens to be a highly volatile product. With the additive, it can be sold as a premium diesel fuel combining high cetane number and high volatility.

The direct result: This refiner reports he has eliminated the special diesel oil run at his plant. Premium grade diesel fuel in this area sells for ½ cent a gallon more than No. 1 heating oil and 2 cents a gallon more than regular diesel fuel.

This premium fuel is said to be receiving good acceptance. Some wholesalers, not wishing to meet the expense of drum deliveries of diesel oil and with insufficiently large storage facilities to receive bulk shipments of premium fuel, can now handle the demands for both premium and regular grade diesel fuels. Engines that require fuel of higher volatility and better ignition quality than that provided for in regular grade of diesel fuels can be supplied easily.

*Richfield Oil Corporation (West Coast).

Saves Storage

Another company reports it has eliminated terminal storage for diesel fuel because of the availability of the additive. Bulk plants need not have separate storage for diesel fuel in addition to that for heating oil; the latter can also be stored for diesel fuel and upgraded to high ignition quality fuel with the addition of amyl nitrate.

From these reports, it appears as if small refiners as well as major companies should benefit from the use of this ignition improving additive. Small orders for the special fuels required in high speed diesel engines may now be filled from regular heating oil. Without special equipment or special runs, the small refiner can round out his products and services to meet demands that would otherwise be uneconomical because of their small size.

Railroads Still Testing

Very lengthy and thorough tests are being carried out currently by the railroads to determine whether synthetic cetane compound operates in all aspects as efficiently as natural cetane in diesel fuel. Conclusive recommendations may be expected soon. * * *

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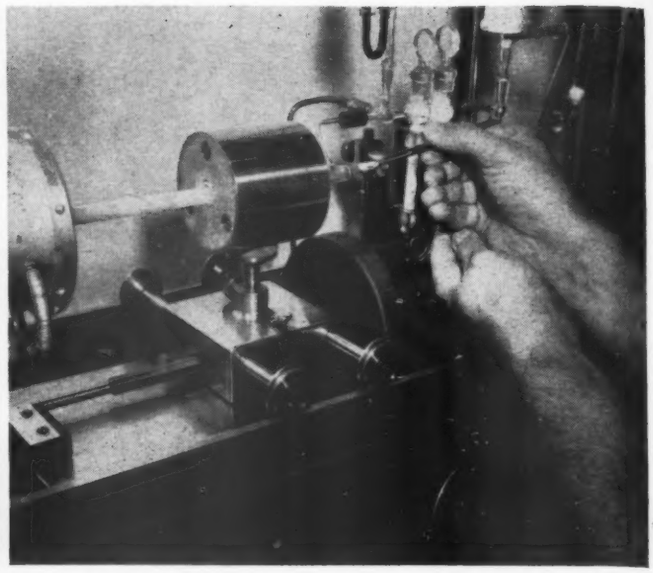
ERVIN STEHR, microchemistry group leader at Beacon, New York, laboratories of The Texas Company, assembles the absorption tubes of an automatic microcombustion train. The apparatus promotes the uniform burning of a sample.



AUTOMATIC FURNACE of the Texaco microcombustion train is shown. Control of rate of burning produces more uniform combustion and frees the operator, shown here placing a sample in the burner, to prepare additional samples.

Microcombustion Train Aids Uniformity of Burning

An automatic microcombustion train for carbon and hydrogen determinations, which permits uniform burning of a sample and frees the operator for other laboratory work, has been designed and built by the Beacon Laboratories of The Texas Company. Chemist Ervin Stehr designed the apparatus that embodies an automatic mechanism to advance the small electric furnace at a rate determined by the progress of the combustion. Design of the train also provides for the adjustment of different units in the system and permits setting up various determinations with the same basic equipment.

The development of the automatic train has enabled Texaco, a pioneer in the use of micro techniques, to step up its volume of analyses, and has added to the efficiency of the microchemical procedures carried out at the main research center of The Texas Company.

P 221.6

Determination of Fluoride in Refinery HF Alkylation Caustic Wash Solutions

MAXEY BROOKE and E. G. CASEY*

In the HF alkylation process in a modern oil refinery it is necessary to scrub some of the product streams and most of the waste streams with a caustic solution to remove traces of hydrogen fluoride. For efficient refinery operation it is desirable to keep a running check on the fluoride concentration of the caustic wash solutions. A number of methods for the volumetic determination of alkali fluorides were investigated and rejected for the following reasons:

a. Frere[1] used yttrium nitrate with methyl red as an indicator. Method is applicable to solutions containing more than 0.025 gr fluorine per 100 ml. In the presence of other alkali salts it is necessary to apply a correction factor.

b. Hoffman[2] precipitated the fluoride as lead chlorofluoride, redissolved the precipitate, determined the chloride by a Volhard titration and calculated the fluorides. The determination requires considerable skill, close pH control and the original precipitate must age several hours.

c. Scott[4] precipitated the fluorides with an excess of calcium acetate and removed the calcium fluoride by filtration. The excess calcium was precipitated as the oxalate and the calcium oxalate was removed by filtration. The excess calcium was determined by titrating either the precipitate or the filtrate with potassium permanganate. The fluoride was then calculated indirectly. This method is both cumbersome and time consuming.

d. Willard[5] titrated the fluoride directly with thorium nitrate using sodium alizarin sulfonate as an indicator. While applicable to very dilute solutions of fluorides, the method could not readily be adapted to this problem. The endpoint is difficult to judge requiring considerable experience and skill in color matching.

In an attempt to develop a rapid accurate test, the Scott method was reinvestigated in connection with the Schwartzenback and Ackermann[3] method for the determination of calcium. This is commonly called the "versenate" method and is based on the property of disodium dihydrogen ethylenediamine (versenate) to form relatively unionized compounds with calcium and magnesium. A dye, Eriochrome Black, which turns from red in the presence of ionized magnesium to blue in its absence is used as an indicator.

Reagents

1. Buffer solution: Mix 67.0 gr ammonium chloride, 570 ml concentrated ammonium hydroxide and 23 ml of 20-22 per cent ammonium sulfide. Dilute to 1 liter, pH = 10.

2. Indicator: Mix 0.5 gr Eriochrome Black T with 4.5 gr hydroxyl ammonium chloride. Dissolve in 100 ml isopropyl alcohol.

3. Calcium Chloride Solution: Dissolve 1.000 gr purified calcium carbon-

*Phillips Petroleum Company, Sweeny, Texas.

EXCLUSIVE

ate in a little dilute hydrochloric acid. Dilute to 1 liter.

4. Versenate Solution; 0.02 N: Dissolve 4.00 gr disodium dihydrogen ethlyenediamine tetracetate and 0.1 gr magnesium chloride in 750 ml water. Standardize as follows: To 25 ml calcium solution, add 1.0 ml of buffer solution and 0.5 ml indicator solution. Titrate with the versenate solution to a blue end point. Using the volume required for titration and the total volume of solution, calculate the volume to which the solution must be diluted to be 0.02 N. (1 ml 0.02 N versenate $\triangleq$ 1 ml calcium chloride solution.)

5. Calcium acetate solution: 0.1 N: Dissolve 4.4045 gr calcium acetate in about 700 ml of water and dilute to 1 liter. Standardize against standard versenate solution. Calculate normality with respect to calcium. Solution is stable for about two weeks.

Procedure

To a quantity of caustic containing 10-50 mg of fluoride, add enough 0.1 N calcium acetate to react with the fluoride and 1-2 ml excess (1 ml 0.1 N calcium acetate $\triangleq$ 2 mg fluorine). When approximate amount of flouride is not known, it is necessary to use several samples, varying the amount of calcium acetate used. If the solution is basic, make slightly acid with glacial acetic acid (litmus paper). Bring the solution to a boil to expel any carbon dioxide. Cool, add 10 ml buffer solution and 0.5 ml indicator solution. If calcium is present, the solution will be red. Titrate rapidly with the versenate solution to a blue end point. In the absence of carbonates the end point is stable for 60-90 seconds. Calculate the fluorides:

$$\text{ppm fluorides} = \frac{[(Ml_c \times N_c) - (ml_v \times N_v)]\ 1900}{\text{ml sample}}$$

Ml_c = ml calcium acetate added.
ml_v = ml versenate used.
N_c = Normality calcium acetate solution.
N_v = Normality versenate solution.

Discussion

The precipitation of calcium fluoride in an alkaline or acetic acid solution proceeds rapidly when the fluoride concentration is above 80 ppm. To check the accuracy and reproducibility of the method, several samples were analized by different operators. Check results are shown in Table 1. A second sample containing 203 ppm F was given to five operators. The results of their tests are given in Table 2.

Interfering materials other than carbonates (which are removed by acidizing and boiling) are not likely to be found in the material being tested. But since phosphates and sulfates interfere in other fluoride tests, a series of tests were made to determine the magnitude of such interference. The results are shown in Table 3.

TABLE 1. Ppm F recovered.

ppm F added	Operator A	Operator B
500	505,505	502,502
392	402,391	414,414
300	315,315	342,334
190	197,197	194,194
85	87,87	87,–

TABLE 2.

Operator	ppm F recovered
A	200,206
C	200,203,204
D	198
E	203
F	202

TABLE 3.

ppm F added	ppm PO_4 added	ppm SO_4 added	ppm F recovered operator A, operator B
500	60	0	513,513
500	0	73	513,505
500	60	73	496,498
392	60	0	414,408
392	0	73	403,380
392	60	73	381,372

Conclusions

A method for the volumetric determination of fluorides has been described. Its accuracy and reproducibility are comparable with existing methods and it offers the advantage of being more rapid and less susceptible to interfering substances.

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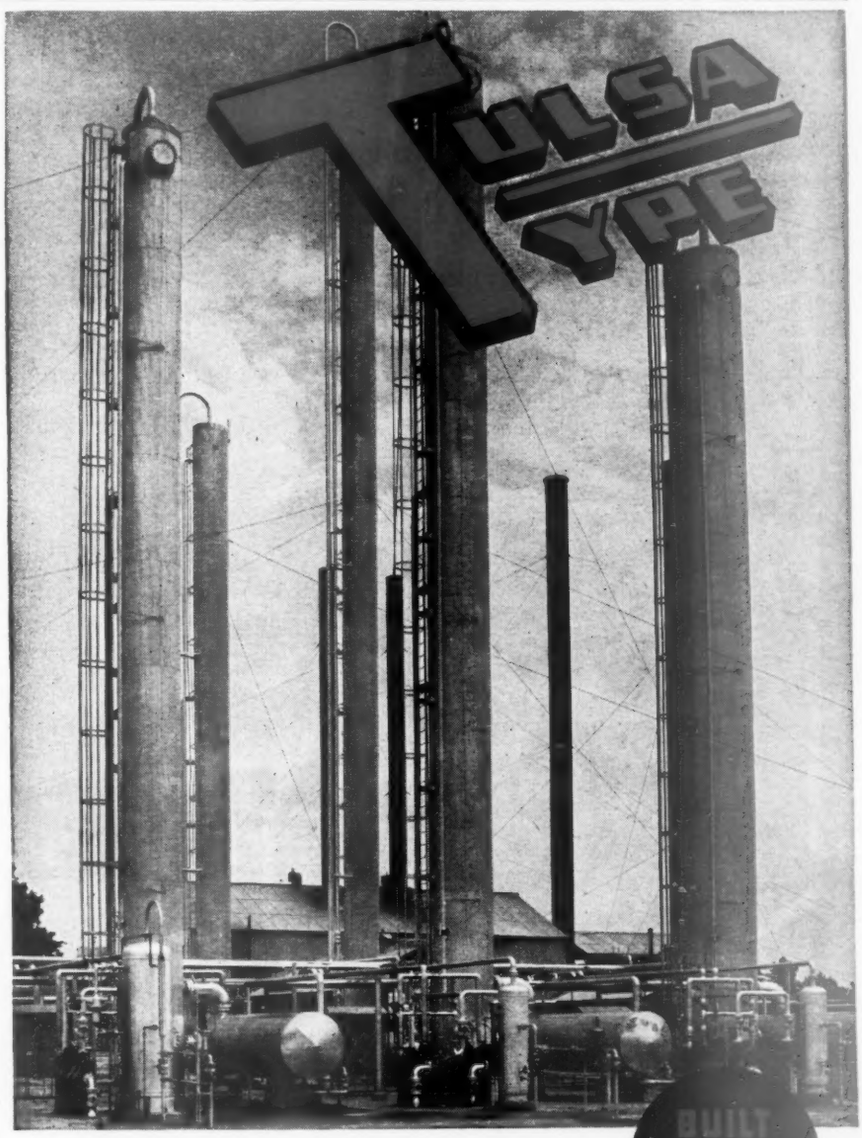
5. Willard, H. H., Ind. Eng. Chem. An. Ed. 5, 7-10 (1933).



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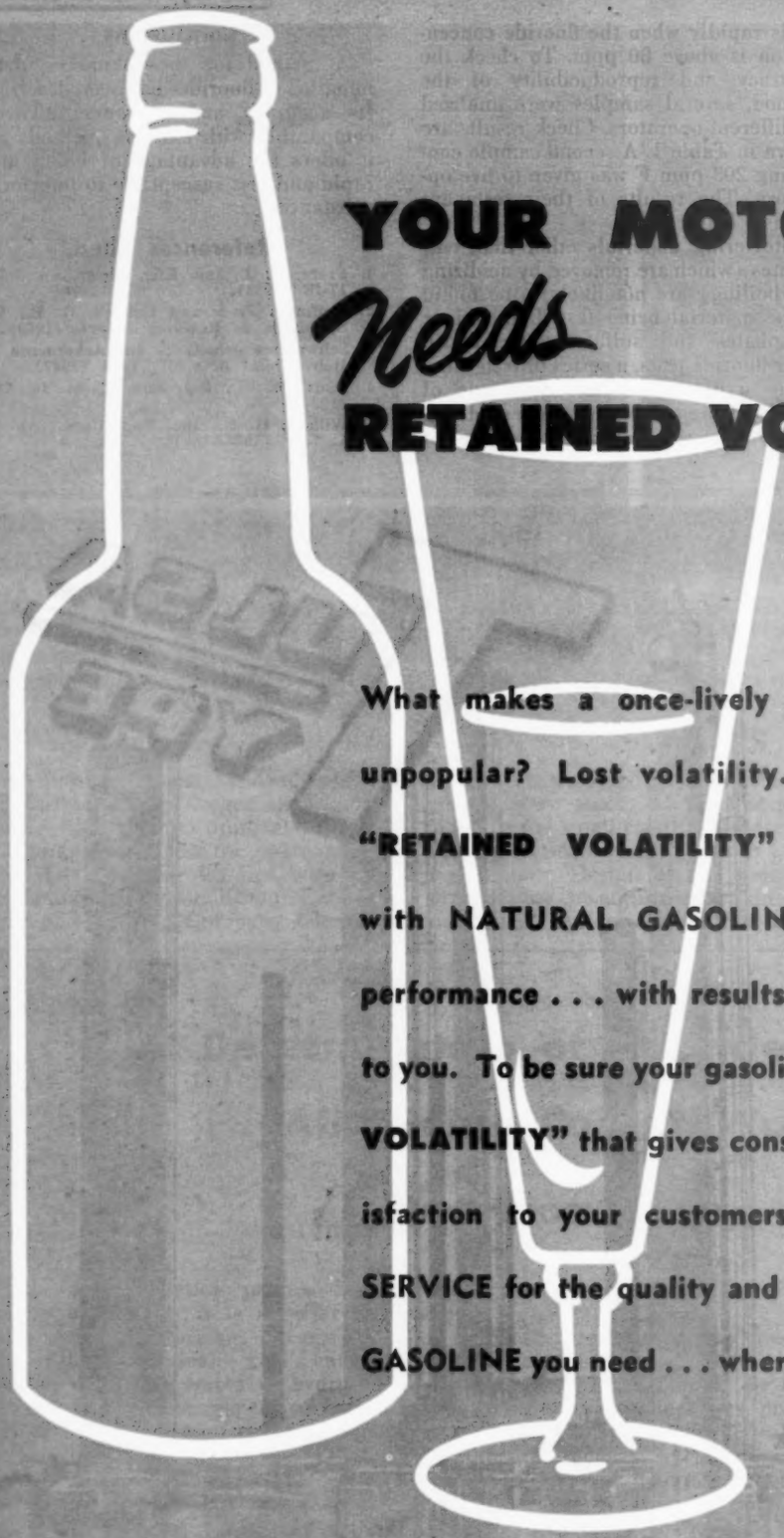

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HUGH SMITH and GEORGE ZORNS[4]

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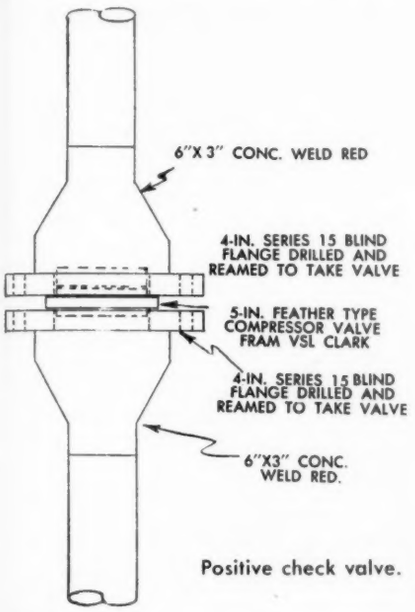

6"X 3" CONC. WELD RED
4-IN. SERIES 15 BLIND FLANGE DRILLED AND REAMED TO TAKE VALVE
5-IN. FEATHER TYPE COMPRESSOR VALVE FRAM VSL CLARK
4-IN. SERIES 15 BLIND FLANGE DRILLED AND REAMED TO TAKE VALVE
6"X3" CONC. WELD RED.

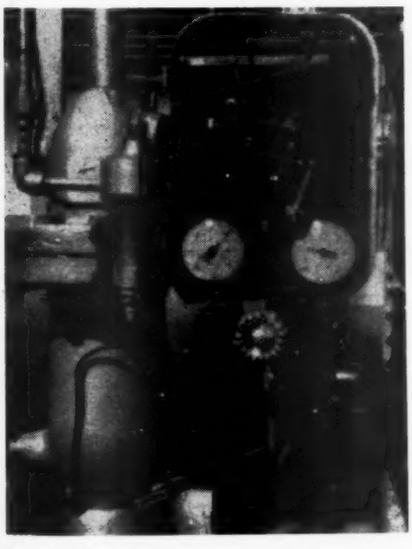
Positive check valve.

[3]Class D, third prize at NGAA—Permian Basin regional meeting.
[4]Superintendent and chief operator, Phillips' Hobbs plant.

Pressure Controller Heater Coil†

OVID PHILLIPS‡

All gasoline plants are constructed so as to be as automatic as possible, thus putting less work on the operators and enabling a large distilling unit to work smoothly with only a few employees. Most of this is accomplished by installing motor valves. The motor valve has a pressure controller to operate it at the desired rate of flow. It is a headache for top personnel to get out of bed at midnight and come to the operators assistance when any number of motor valves are not functioning properly due to freeze-ups during cold weather. In examining the cause of these freeze-ups, we have discovered that a large part of the trouble was caused by moisture getting to the diaphragm and the bourdon tubing of the pressure controller, even though we have air and gas dryers. When this moisture would freeze, it would put the pressure controller out of operation and render the motor valve inoperative. To eliminate this trouble, two holes were drilled in the back on the pressure controller case, one on each side of the diaphragm housing, so that copper tubing could be inserted through one side and wound around the diaphragm housing and out the other side. Steam is turned on to flow through the copper tubing, thus keeping the inside of the pressure controller case at a higher temperature and preventing any freeze-ups as far as the controller is concerned. We have had approximately 50 of these in operation at our plant for some time, and have practically eliminated this kind of trouble. This hook-up seems expensive, but the time and money saved makes its cost look very small.



†Class A, second prize, NGAA Kinks Contest.
‡Warren Petroleum Corp., Gladewater, Texas.

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These rules and formulas apply to any kind of solid or liquid fuel—coal, oil, wood, refuse, etc. Find the temperature of the air entering the furnace and subtract that temperature from the temperatures of the chimney gas. Multiply that difference by the number of pounds of gas per pound of fuel. Then multiply by 24. Lastly, divide by the heat value of the fuel. The quotient is the per cent of loss.

For example if the temperature of the chimney gas is 650 F; air entering furnace 70 F; 19 lb of gas per pound of fuel; and the fuel contains 14,000 Btu per pound, we have this:

$$\frac{(650-70)\times 19\times 24}{14{,}000}$$

= 18.9 per cent loss

Now let us suppose that the installation of baffle walls reduces the flue gas temperature to 500 F, we then have this:

$$\frac{(500-70)\times 19\times 24}{14{,}000}$$

= 14 per cent loss

The saving effected by the baffles therefore is:

18.9 per cent — 14 per cent = 4.9 per cent saving.

The above manipulation makes it clear that a short cut method is to do it this way:

$$\frac{(650-500)\times 19\times 24}{14{,}000}$$

= 4.9 per cent saving

In other words, the following rule gives quickest results:

Rule: Multiply the reduction in temperature of chimney gases due to the fuel saving device by the number of pounds of gas per pound of fuel. Multiply that by 24. Then divide by the heat value of the fuel in Btu per pound. Result is the saving in per cent.

The formula is:

$$\frac{24\,W(T-t)}{H} = \text{per cent saving effected,}$$

where,

T = temperatures of exit chimney gases before installation of the fuel saving device;
t = temperature of exit chimney gases after installation of the fuel saving device;
W = pounds of gas per pound of fuel;
H = heat value of the fuel, Btu per pound.

—WFS.

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REFINING AND PETROCHEMICAL PERSONALS

▸ **Dr. William J. Sparks,** co-inventor of Butyl synthetic rubber, has been selected to receive the 1954 Gold Medal of The American Institute of Chemists, it was announced recently.

Dr. Sparks is director of the chemical division and coordinator of exploratory research for the Standard Oil Development Company, central research and engineering affiliate of Standard Oil Company (New Jersey). He is the 26th person chosen for the annual award.

The announcement was made by Dr. Gustav Egloff, chairman of the medal award committee, who said Dr. Sparks was cited "as an eminent chemist who has striven unceasingly for the promotion of the science of chemistry and the professional advancement of the chemist." The medal will be presented at the Institute's annual meeting at Asbury Park, New Jersey, in May.

▸ **H. E. Handy** has been appointed to the newly established position of manager of The Ohio Oil Company's Robinson, Illinois, refinery. Handy has served as refinery superintendent for the past seven years.

D. L. Winsett, assistant refinery superintendent, succeeds Handy as refinery superintendent.

Handy recently completed 30 years of service with The Ohio Oil Company, most of it at the Robinson refinery. Following his graduation from the University of Illinois, he began work as an engineer in the production department at Marshall, Illinois. He went to Robinson in 1926 as a refinery engineer and advanced to refinery superintendent in 1947.

Winsett received his Masters degree in chemistry at Oklahoma A and M, then joined Transcontinental Oil Company in 1925. When The Ohio Oil Company purchased the assets of Transcontinental in 1930, he continued as a chemist at the Del Rio, Texas, refinery. He was appointed assistant superintendent at the Robinson refinery in 1939.

▸ **O. M. Williams,** who was assistant to the vice president of Shell Chemical Corporation, has been appointed manager of the company's plant at Dominguez, California. Williams succeeds **Glenn Purcell** who has been appointed manager of the company's plant at Houston, Texas.

Williams received a degree in engineering from Stanford University. He joined Shell in 1935, and rose through positions of increasing responsibility. In 1946 he was named as plant manager at Martinez and in 1951 became assistant to the vice president at the company's New York head office.

▸ **S. R. McMurry,** manager of Cities Service Oil Company's Ponca City, Oklahoma refinery, has been transferred to the Bartlesville headquarter offices on special assignment, according to Lee N. Haugen, vice president for refining operations.

D. R. McConnohie of Bartlesville, assistant to the general superintendent of refining, will assume McMurry's duties as manager of the Ponca City refinery.

McMurry was first employed by Cities Service in 1924 and was transferred to Ponca City in 1950, after serving 20 years in various operational and supervisory positions at the company's East Chicago, Indiana, refinery.

McConnohie joined Cities Service at its East Chicago refinery in 1936 after graduating from Michigan State College. He first served as pressure still operator and advanced through various positions to head the plant's cracking department. In 1951, he was transferred to Bartlesville as assistant to the general superintendent.

▸ **George H. Barlow** has been appointed purchasing agent by Jefferson Chemical Company, Inc. He succeeds **Robert C. Brown,** who becomes purchasing agent of American Cyanamid Company's industrial chemicals division. Barlow, who has been associated with Jefferson since March, 1945, moves to his new post from that of chief job engineer for the company, in which capacity he was in close liaison with purchasing department activities.

▸ **Herschel Y. Hyde,** vice president in charge of manufacturing, Western division, Tide Water Associated Oil Company, has been assigned the responsibility of planning and developing programs of the refining activities of all divisions of the company.

Hyde, a graduate of the University of California and Massachusetts Institute of Technology, has been in the service of Tide Water for 26 years, commencing as a research chemist in the company's refinery at Avon, California. He served in various positions in the Research and Development Department and became Supervisor of that department in 1929. Since 1946 Hyde has served as vice president in charge of manufacturing, Western division.

Hyde will continue to make his headquarters in San Francisco.

W. G. Copeland

A. Voorhies, Jr.

H. G. Teverbaugh

▸ **W. G. Copeland** has been appointed general superintendent of Texaco's Port Arthur Works, Port Arthur, Texas. Copeland was first employed by Texaco in 1926 as a helper in the laboratory at the company's Port Arthur, Texas refinery and, after his graduation from Rice Institute in 1927, as a chemist there. He advanced through various posts in the refining department and was transferred to New York in 1934 and to a Texaco affiliate in France in 1939. In 1950, he was named superintendent of the company's Eagle Point Works at Westville, New Jersey.

Several other promotions in Texaco's refining department were announced.

E. W. McNealy, who has been assistant superintendent of Lockport Works, Lockport, Illinois, has been promoted to superintendent of Eagle Point Works, succeeding Copeland. A graduate of Rice Institute, McNealy has been with the company for more than 21 years.

J. C. Williams, formerly assistant superintendent of West Tulsa Works, has been named to succeed McNealy. Williams earned a BS degree from Rice Institute and a MS from MIT. He has been employed by Texaco since 1941.

F. D. Davis, who was assistant superintendent of Casper Works, Casper, Wyoming, has been named assistant superintendent of West Tulsa Works, succeeding Williams. Davis was graduated from Stevens Institute of Technology. He has been with Texaco since 1932.

V. K. Brandenburg, formerly supervisor of operations at Lawrenceville Works, Lawrenceville, Illinois, has been promoted to assistant superintendent at Casper Works, succeeding Davis. Brandenburg received his MS from Georgia School of Technology. He has been with Texaco for more than 18 years.

▸ **Alexis Voorhies, Jr.,** director of the Esso Laboratories, Baton Rouge, Louisiana, is the recipient of the Louisiana Engineering Society's Technological Achievement Award for 1953.

The award is made annually to an engineer in the state for distinguished technological advancement or discoveries that contribute to the field of engineering. Voorhies was selected for the honor for "his continued interest in and contribution to the application of the fluidized technique for solids handling and his interest in the problems and development of technical employees."

Voorhies is a graduate of Louisiana State University and of Loyola University in New Orleans.

He joined Esso at Baton Rouge in 1930 as an engineer, subsequently serving in various technical and supervisory positions. He was named director of the laboratories in 1947 after serving as associate director for a number of years.

▸ **Harold G. Teverbaugh** has been named assistant manager of the gas division of Texas Natural Gasoline Corporation.

He resigned recently as project engineer with Sunray Oil Corporation to accept his new duties.

Teverbaugh was graduated from Oklahoma Agricultural and Mechanical College and prior to his employment with Sunray, was associated with Stanolind Oil and Gas Company as junior engineer. In 1948, he joined Sunray as field engineer. He was promoted to plant engineer in 1949 and in 1950, to plant superintendent. Later was made project engineer.

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HERBERT S. CHASE, vice president, presents gold watches to William L. Gorman and Charles W. Hoffacker, upon completion of more than 50 years with Tide Water.

William L. Gorman and **Charles W. Hoffacker,** each of whom has completed more than 50 years of continuous service with Tide Water Associated Oil Company, received gold watches at a special retirement ceremonies in the New York office recently.

Gorman, who joined the company in 1901, had 52 years of continuous service. At the time of his retirement he was a member of the Bayonne, New Jersey, refinery's plant protection department.

Hoffacker, who has the longest service record of any company employee, began in 1895 in the process accounting department of the Bayonne, New Jersey, refinery, where he served in responsibile positions until his retirement, 58 years later.

R. W. McOmie

P. J. Merkus

C. M. Fabian

R. W. McOmie, manager of Shell Oil Company's Wilmington, California, refinery, has been appointed manager of the new refinery the firm is constructing at Anacortes, Washington.

P. J. Merkus, assistant to the vice president in charge of manufacturing, will succeed McOmie as manager of the Wilmington refinery.

While the refinery at Anacortes is being constructed, McOmie will devote his full time to coordinating various activities in connection with the project, and developing and training of the operating organization.

McOmie received a degree in chemistry from Stanford University, California, and began his Shell career in 1927 as a chemist at the company's Martinez, California, refinery. He was named refinery manager at Wilmington in 1946.

Merkus received a PhD degree in chemical engineering from the University of Michigan, and joined Shell in 1934. He became assistant to the manufacturing vice president in 1946.

Carl M. Fabian has been promoted to general superintendent of Magnolia Petroleum Company's Beaumont refinery. Fabian succeeds **J. L. Heath,** present superintendent who retired January 1 after almost 39 years of service with Magnolia.

Fabian has been with the company at the Beaumont plant for 34 years. He joined Magnolia in 1919, a week after his graduation from Texas A and M College.

Heath was employed by the company in 1915. In 1947 he was advanced to general superintendent of the Beaumont refinery.

N. B. Marchbanks has been named superintendent of Magnolia's Fort Worth refinery. The promotion was made upon retirement from active service of **J. W. Folmar,** who has been superintendent at Fort Worth for nearly 15 years.

Marchbanks joined Magnolia in 1916, in Dallas, and about a year later was transferred to the company's Beaumont refinery.

J. D. Wall, assistant to the mechanical superintendent at the company's Beaumont refinery, is to succeed Marchbanks. Wall attended Millsaps College, and was graduated from Louisiana State University. He joined the company's technical department at Beaumont in 1946. While on the technical staff there he helped handle process engineering assignments for the Fort Worth refinery. He was promoted to his former post last June.

Folmar retired from active service after more than 41 years service. He began his career with Magnolia in 1912 as a pipe fitter helper at the Beaumont plant. He was transferred to the Fort Worth refinery as superintendent in 1939, and has held that position ever since.

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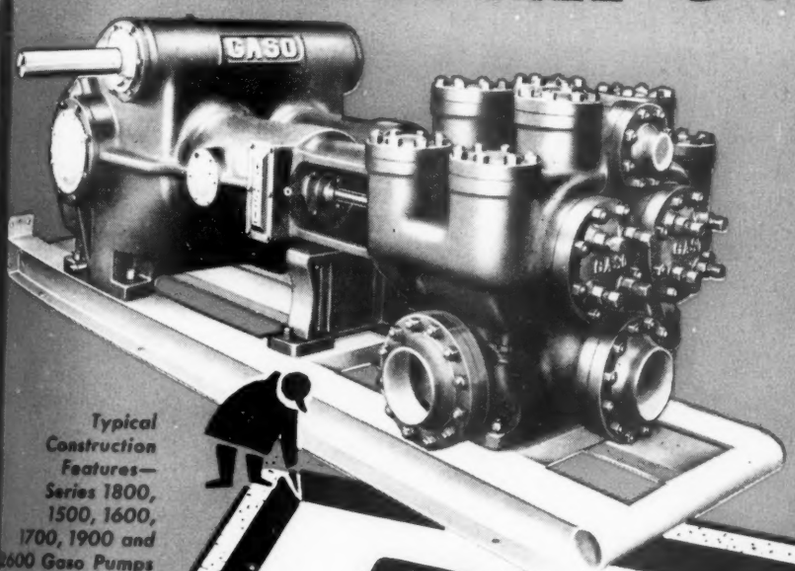

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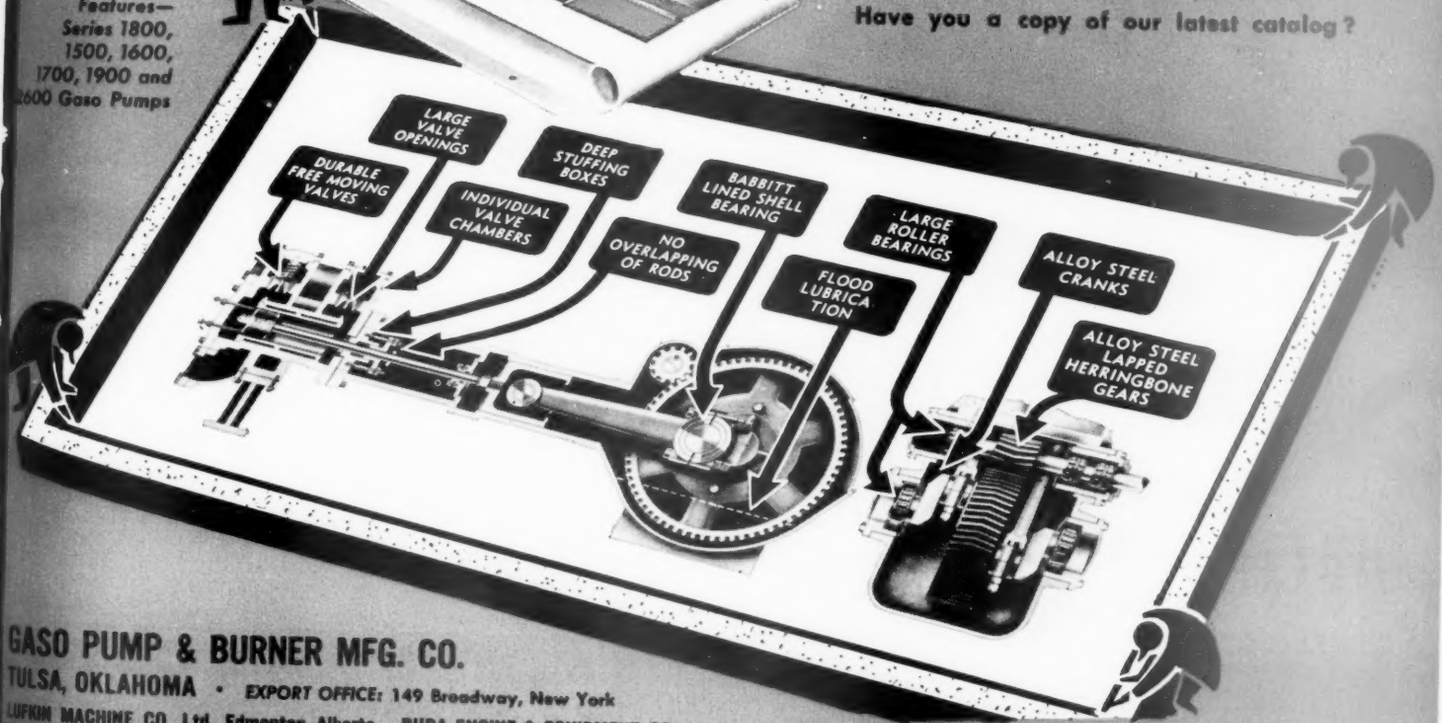

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To obtain more information on products advertised see page E-69

$35,000,000 Gas Line

Application to build a 708-mile pipe line system entirely in the state of Colorado has been made to the Colorado Public Utilities Commission by a newly-formed company, Colorado-Western Gas Company, headed by John A. McGuire of Dallas, Texas. The proposed system would include a 454 mile line from the Ignacio gas fields in the southwest corner of the state to Denver, and another 254 miles in lateral lines.

★ ★ ★

Progress on Yellowstone

Work on the 540-mile, 10-in. Yellowstone Pipe Line between Billings and Spokane is approximately 25 per cent complete, but the tough part is to come, say engineers of Continental Pipe Line Company, handling the overall engineering and construction supervision. Remaining are the crossing of the Rockies and Continental Divide, eight major river crossings, and 30 crossings of the twisting Coeur d'Alene River. The line is to be completed in September 1954, and will have an initial capacity of 30,000 bbl per day.

★ ★ ★

6,000,000 Bbl Line Fill

Oil is now moving through the longest crude oil pipe line in the world—the 1770-mile Interprovincial-Lakehead 30-in. system between Alberta and Sarnia, Ontario, which traverses the U. S. for 645 miles. The final segment of the big system was completed in November and has been undergoing testing and line fill operations since. Nearly 6,000,000 bbl of crude were needed for initial line filling. The pipe line now has a capacity of 178,000 bbl per day out of Edmonton.

★ ★ ★

Study Convertible Line

Six prominent gas company officials have been named as consultants to the Petroleum Administration for Defense in a study aimed at exploring the possibility of a large capacity gas line between the Texas-Gulf and East Coast that could be converted to crude oil service in event of war.

Named to the group were Walter E. Caine, Texas Eastern; John H. Carson, East Ohio Gas; J. J. King, Tennessee Gas; A. Dale Green, United Gas Pipe Line; Walter H. Davidson, Transcontinental Gas Pipe Line and Wilbur T. Shinholser, Columbia Gas System. Joseph A. LaFortune, PAD chief, said the group will meet in Washington soon to outline their work.

★ ★ ★

ICC Won't Appeal

By a vote of 10 to 1, the Interstate Commerce Commission has decided not to appeal to the U. S. Supreme Court a district court ruling against reduction of railroad rates on southwest oil movements designed to forestall construction of a proposed pipe line between El Paso, Texas, and Tucson and Phoenix, Arizona.

★ ★ ★

Big Gas Sales Increase

Sales of gas by utilities and pipe lines will be almost 26 per cent higher in the next two years, the AGA estimates, in a recently published report. A total of 71.6 billion therms are expected for 1956, an increase of 33 per cent over 1952 sales and 25.8 per cent of 1953's 57 billion therms.

★ ★ ★

Would Hurt Tanker Fleet

Construction of the proposed "super inch" pipe line from the Southwest to the Eastern Seaboard as a defense measure at the present time might destroy the American flag tanker fleet, according to William C. Kinsolving, president of Sun Pipe Line Company. He pointed out that tankers could not compete on a cost basis with a pipe line capable of moving a million barrels of oil a day. Yet a strong American tanker fleet, he added, is a vital need in fighting a global war.

★ ★ ★

Texas Line Building Soon

A new 208-mile, 20-in. crude oil pipe line with an initial pumping capacity of 122,000 bbl daily will be built by Magnolia Pipe Line Company from Corsicana to Beaumont, according to L. H. True, company president. Construction is due to begin during second quarter of the year and will take about six months to complete. Six 122,500-bbl tanks with connecting pipe lines will be built at the Beaumont refinery. New pumping equipment will be installed at Corsicana, together with necessary tank farm lines and two new 120,000-bbl tanks.

Lay Deepwater Lines

Work is underway on the simultaneous laying of two deep water lines under the mile-wide Delaware River for the Harbor Products System, a Philadelphia-New Jersey link for all-weather moving of petroleum products. The new common carrier will connect the nation's second largest refining center and its principal marketing area. The 16-in. line will connect also with the new Buckeye Pipe Line. It is jointly owned by Gulf, Sinclair, and Texas companies.

★ ★ ★

Plains Lines Sold

Sale of the Plains Pipe Line Company to Clint Murchison interests of Dallas, Texas, has been reported by Robert Olds, president of the Northeastern Wyoming Oil Producers Association. The 250-mile line, made up of 4, 6, and 8-in. pipe, has a daily capacity of 17,000 bbl, and links one of the richest fields in the Rocky Mountain area to refining centers. The line, which operates only in Wyoming, connects with the Rocky Mountain Pipe Line Company and the Ohio Pipe Line Company. A looping program to increase capacity is planned.

★ ★ ★

Corrosion Talks at NACE

Mutual discussions of pipe line corrosion problems, popular at previous NACE meetings, will again be featured at the association's 1954 tenth annual conference in Kansas City, March 15-19. Eight discussion groups will be held, for both members and non-members. Experienced corrosion engineers will act as moderators and panels of the nation's best known experts on underground corrosion will be available for consultation.

★ ★ ★

Accounting Rules Easier

Notice of a proposed rule that would amend the FPC's general rules and regulations relating to accounting for inventories of natural gas stored underground, part of the uniform system of accounts for natural gas companies, has been issued by the FPC. The change would allow the transmission and storage expenses to be included in the pricing of inventories of gas stored underground. This is not now done.

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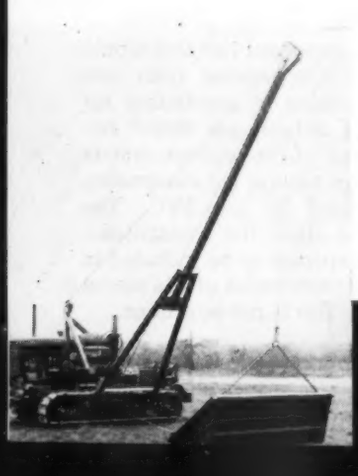

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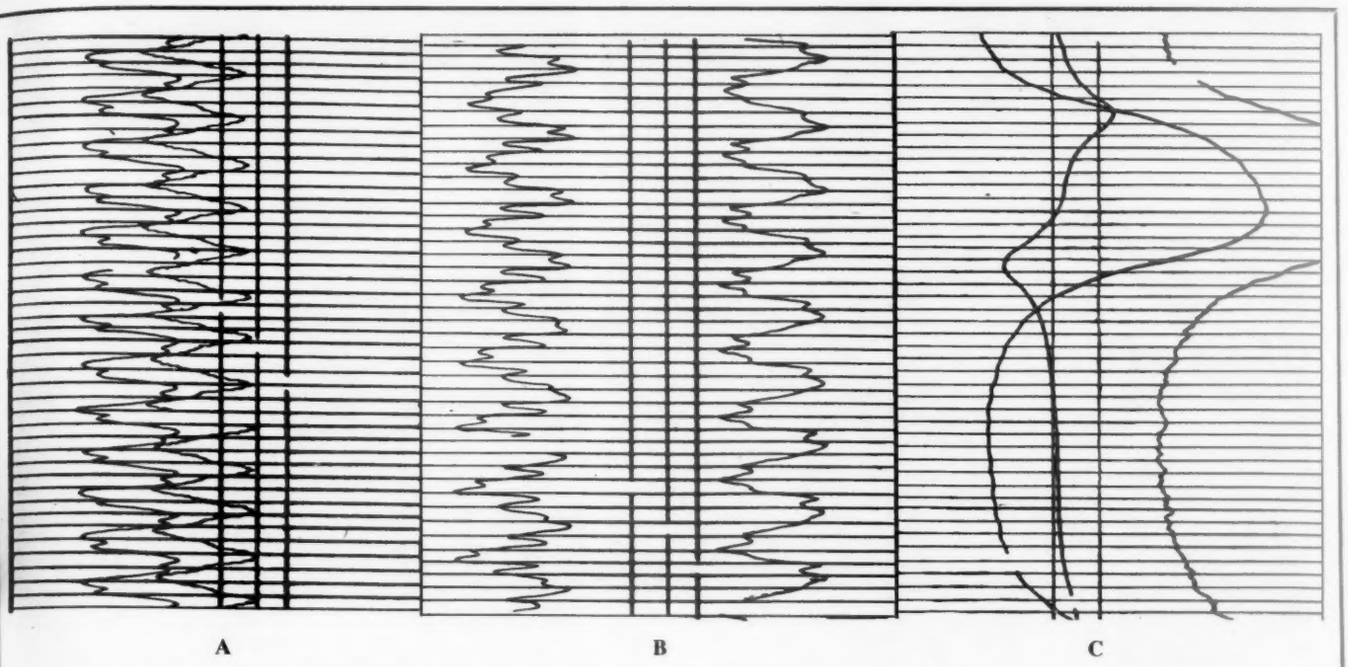


A B C

FIG. 1 A AND B show typical traces of pressure surges in test pipe line used in research studies. C shows a typical water hammer surge. Recordings were made on an oscillograph. In test setup, a SR-4 pressure cell was connected to test line in which pressure was measured. Leads from cell were connected to a recording oscillograph through an amplifier, making traces by means of a beam of light directed on a strip of photo-sensitive paper moving at a constant rate through machine.

New hydraulic wave theory developed

Surge Mysteries Nearing Solution

Oklahoma A & M Research Team

Pipe line company-sponsored research program finds key to problem of costly surges through development of new hydraulic wave theory; correction devices second phase of program

EDWIN J. WALLER

PRESSURE surges—one of the toughest problems faced by the pipe line industry—are being studied in an engineering research project at the Oklahoma Institute of Technology, Oklahoma A&M College's school of engineering, at Stillwater, Oklahoma.

Sponsored by four major pipe line companies, a two-year research project, just completed, has led to the development of a new theory that can be used to analyze and predict pressure surges. Two of the companies have underwritten the continuance of the expanded second phase of this work. Financial support by others interested is anticipated before this phase progresses too far.

Pressure surges (unsteady pressures in a fluid) are transmitted through fluids in the form of waves that have definite sizes and speeds according to the system. Ocean waves are perhaps the most common example of this phenomena.

In a pipe line system, these pressure waves create the condition called water-hammer, which is the familiar knocking that occurs when a valve is closed suddenly while fluid is flowing through the line.

EXCLUSIVE

The major cause of these pressure surges in pipe lines in some instances is the system's pump. When the pump exerts an uneven pressure on the oil in the line, pressure waves are created and result in:

1. Points of extreme pressure change in the pipe line which may cause failure of the pipe. If the pipe fails, repairs, loss of product and time result.

2. Use of heavier materials in construction of system in order to withstand strain of extreme pressures.

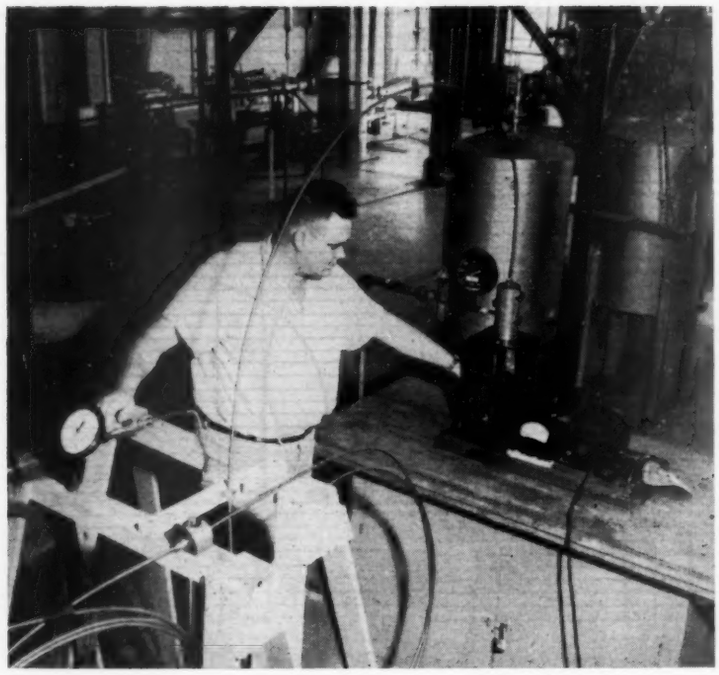


FIG. 2. SECTION of the simplified pipe line system used for pressure surge research studies. On table in foreground is a surge generator, being adjusted by the author.

FIG. 3. RESEARCHERS Norton, Fristoe, and Waller with one of the two, 350-gal tanks used in the new test loop now being completed.

3. Decreased capacity in line. If pressure fluctuations were not present, flow capacity of system could be increased.

4. If surges could be removed, an increase in the efficiency of pump operation would also be possible.

Pressure surge research at OIT is being conducted by a team led by Professor Harold T. Fristoe, school of electrical engineering, and composed of Professors J. R. Norton, general engineering, and Edwin J. Waller, civil engineering.

Development of a new pressure surge theory began when one of the group (Fristoe) noticed the similarity in shape of curves from tests of pipe line pressures and curves of electrical transmission line voltages.

Attacking the problem in the light of this observation, the research team has evolved a hydraulic wave theory based on mathematical methods which are used also in the analysis of heat flow, electrical flow, and acoustics.

Not only the theory but corrective filters suggested by the theory have been checked on a simple laboratory pipe line system, and laboratory results have been acknowledged as successful by engineers from the sponsoring companies.

In the experimental setup at OIT, pressure waves have been reduced as much as 95 per cent. Although still in the preliminary stage, this research may bring reduced operating costs and additional profits to the pipe line industry.

We usually think of most fluids as relatively incompressible, and if the volume of the fluid is small enough, this is approximately true; however, when we consider movement of larger volumes of fluid, the equation that is used to describe the motion of the fluid does not always give the actual conditions that exist. The reason for inability to predict what will happen to fluids in motion by the equation of steady flow of a perfect fluid is indeed simple. In the first case no fluid is perfect, and second the flow in most cases is not steady. We have simply overstepped the limitations of our assumptions on which the steady flow equations are based.

In order to see where the analysis of a perfect fluid deviates from the fluids encountered in actual practice, it is necessary to return to the fundamental theory of fluid dynamics, and analyze the assumptions made in the general case which reduced the theory, so that it would apply to the actual case. This we have done and a brief resume of the theory which pertains to surges in pipe lines follows.

The term "pressure surges" is used to describe the phenomena that occurs in fluid systems when that system's components tend to act independently of the system as a whole. It seems that the term "pressure surge" is used to define any change in pressure from some reference, whether it occurs only once or is repeated at a definite frequency. Both are cases of unsteady pressure variation from some reference. There are two basic classifications of unsteady pressure variations—transient and periodic.

The transient or "water-hammer" type of unsteady pressure is well known. The re-occurring or steady state type of unsteady pressure is found in most systems, and is basically a vibration. Any type of periodic phenomena may be represented by a Fourier's Series, which is obtained by analyzing the predominant harmonics present. The simplest curve that can be represented by a Fourier's series is a sine curve. If the steady state condition of a pressure variation is present in a vibrating fluid system, and if a harmonic analysis is made, it is found that the major frequency of vibration is the same as that of some machine which in

The Author

Edwin J. Waller is assistant professor in the Oklahoma Institute of Technology, School of Civil Engineering, Stillwater, Oklahoma. He is assistant project leader on the pressure surges research project. Waller attended Oklahoma A&M College, Stillwater, receiving B.S. and M.S. degrees in general engineering from the OIT. A World War II veteran, he served four years with the army field artillery, three of them in the European theater of operations. The present surge research study is based on research carried out by Waller for his master's thesis.

general practice is considered outside of the fluid system.

A positive displacement pump operating in a pipe line will cause a repetitive change in pressure in the pipe line. This is an example of unsteady pressure variations. Let us examine more closely a pipe line system in which a positive displacement pump operates.

Characteristics of the Pipeline System

From the theory of three dimensional flow of a fluid, there are two basic equations that are formed by the consideration of the kinetics and kinematics of the fluid. They are the dynamic equations and the equations of continuity.*

$$\left.\begin{aligned}\frac{du}{dt} &= f_1(T, \rho, x, y, z)\\ \frac{dv}{dt} &= f_2(T, \rho, x, y, z)\\ \frac{dw}{dt} &= f_3(T, \rho, x, y, z)\end{aligned}\right\} \quad . \quad . \quad . \quad (1)$$

$$\frac{\delta\rho}{\delta t} = \frac{\delta(\rho u)}{\delta x} + \frac{\delta(\rho v)}{\delta y} + \frac{\delta(\rho w)}{\delta z} \quad . \quad (2)$$

Where u, v, w are the velocities in the x, y, z direction, ρ is the density, T is the shearing stress. Equations (1) and (2) may be simplified by the following assumptions.

1. The principle of superposition holds for this case. The velocities u, v, and w, and the pressure P have mean values which cause a mean flow condition to exist in the system simultaneously with a variable flow condition caused by the deviation from the mean value of u, v, w, and P.
2. The mean flow of a fluid in the pipe line is in one direction.
3. The elasticity of the fluid can be expressed in terms of the density and pressure.
4. The stress on the mass of fluid under consideration can be expressed in terms of the deformation.
5. The effect of turbulent motion on the mass may be expressed in terms of the deformation of the mass.

By using the above assumptions in conjunction with equations (1) and (2) the equations of motion of the fluid are reduced to,

$$\frac{\delta P}{\delta x} + Rq + \frac{\rho}{A}\frac{\delta q}{\delta t} = 0 \quad . \quad . \quad . \quad . \quad (3)$$

$$\frac{\delta q}{\delta x} + \frac{A}{K}\frac{\delta P}{\delta t} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Where p and q are the variation of pressure and volume current from their mean values, K is the bulk modulus of elasticity of the fluid, A is the area of the pipe, and R is the dissipation function.

*Lamb, Horace; "Hydrodynamics" Dover Publications 1945, Articles 7 and 328.

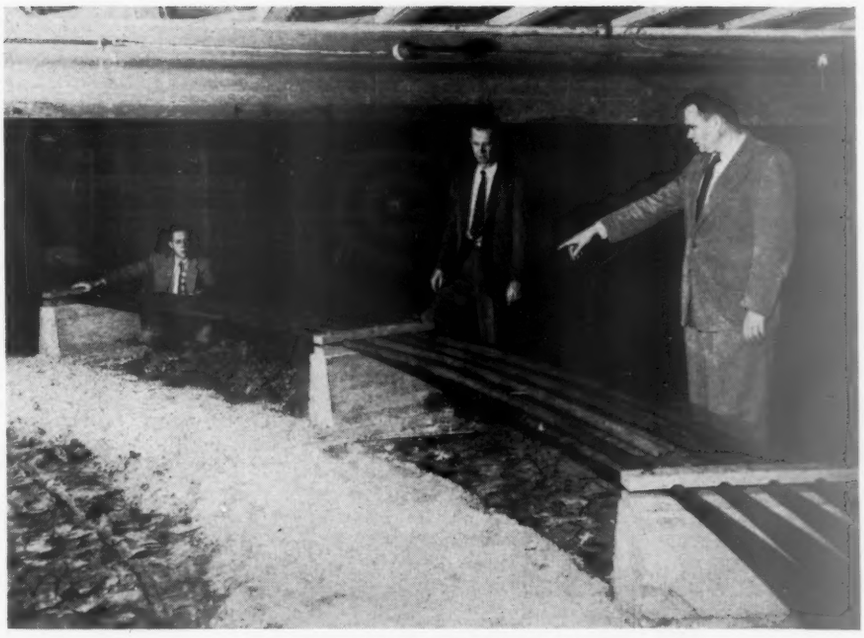


FIG. 4. SECTION of 2100 ft test piping loop to be used in second phase studies. Pipe diameter is standard 1½-in.

Equations (3) and (4) may be solved when the proper boundary conditions are evident. For a long pipe line system with the conditions $x = 0$; $p = \overline{P_r}$; $q = \overline{Q_r}$; and $x = l$; $p = \overline{P_s}$; and $q = \overline{Q_s}$; they become,

$$p = \overline{P_r}\,\mathrm{Cosh}\,\gamma x + \overline{Z_c}\,\overline{Q_r}\,\mathrm{Sinh}\,\gamma x \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$q = \overline{Q_r}\,\mathrm{Cosh}\,\gamma x + \left(\frac{\overline{P_r}}{\overline{Z_c}}\right)\mathrm{Sinh}\,\gamma x \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

or

$$p = \overline{P_s}\,\mathrm{Cosh}\,\gamma(l - x) - \overline{Z_c}\,\overline{Q_s}\,\mathrm{Sinh}\,\gamma(l - x) \quad . \quad . \quad . \quad (7)$$

$$q = \overline{Q_s}\,\mathrm{Cosh}\,\gamma(l - x) - \left(\frac{\overline{P_s}}{\overline{Z_c}}\right)\mathrm{Sinh}\,\gamma(l - x) \quad . \quad . \quad . \quad (8)$$

Where $\overline{P_r}$, $\overline{Q_r}$, $\overline{P_s}$ and $\overline{Q_s}$ are values of the pressure variation and volume current at the receiving end and sending end respectively, and γ is the propagation constant.

The physical significance of equations (5) to (8) is that in a long pipe line, there is a series of traveling waves so arranged in magnitude that they appear to be standing at certain points in the line. The waves travel at a definite speed and change in magnitude depending on the value of the propagation constant. In any given system, if there is no change in the physical constants given in equations (3) to (8), then the system will not change. The system can be analyzed for the points of high pressure variations and when they occur at undesirable places in the system, they can be adjusted.

Adjustment of the System

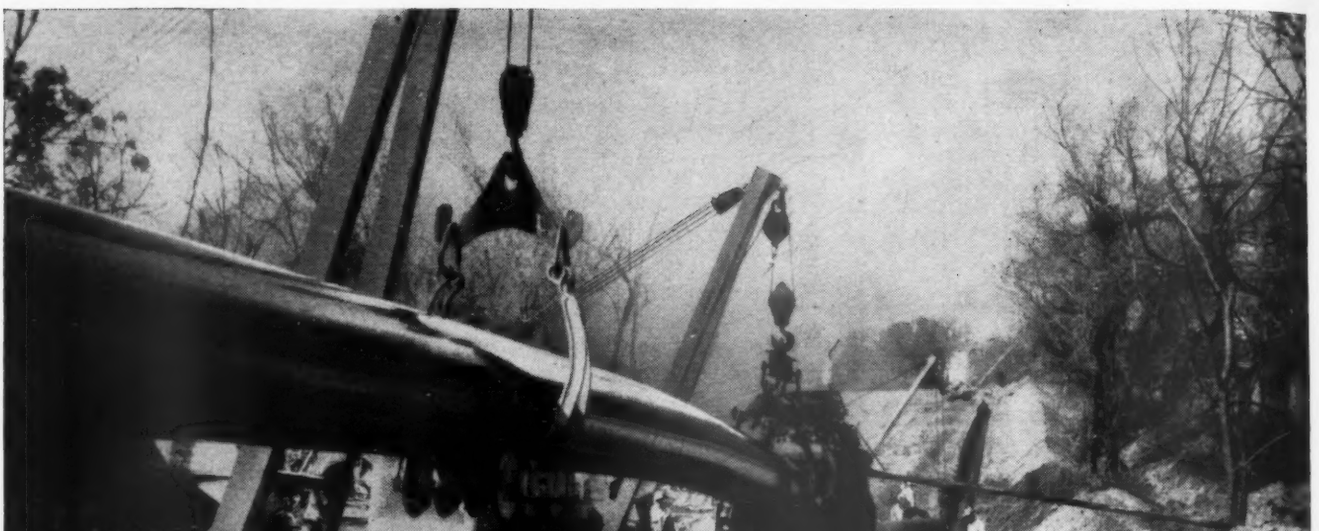
There are three alternatives to be considered when adjusting the system for control of pressure variations. They are:

1. After an analysis has been made and it is found that the pressure variations are not likely to cause sufficient damage to the system to warrant their complete removal, the system may be allowed to operate with the variations present.

2. It is found that damage to the system (pumps, pipe, etc.) may occur, but it is desirable to decrease the pressure variations to a point where the damage would be small in comparison to the original condition.

3. It is desirable to completely remove the pressure variations.

In all of the above cases, the pipe line system must be analyzed, either mathematically or experimentally, to determine the relationships of the constants R, ρ/A, and A/K (equations 3 and 4). The proper values of these constants must be added to the system to obtain desired effects. This may be done by considering the pipe line system as a vibrating system, and the device that changes the constants of the system is the matching or balancing system. With the proper values of friction, inertia, and elasticity, the matching device may "tune" the pressure variations or change them to any desired value. * *



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"Hot Tapping" Symposium—Part II

HOT TAP CONNECTION DESIGN IN HIGH PRESSURE PIPE LINES†

A. J. DEL BUONO,[1] P. L. VISSAT,[2] F. S. G. WILLIAMS[3]

Abstract

This paper presents a review of the forces acting on the branch connection in a pipe line; an analysis of the stress conditions related to such connections; suggests a design approach aimed at keeping the stress levels around branch connections in harmony with the stress levels common in high pressure pipe lines and, finally, discusses various methods of meeting these design requirements through the use of field fabrication with or without manufactured fittings especially designed for the purpose. In addition, the authors have presented a digest of investigative work done by their company and others, bearing on this subject.

BRANCH connections are so common in piping work that many engineers and operators who gain their experience with piping in the low or moderate pressure fields of usage, fail to appreciate the hazards that surround such branch connections in high pressure systems. Unless the fundamentals of design are understood, the precautions necessary to match design and construction methods to these conditions, are often not taken.

The engineering background comes from the pressure vessel field where the diameter of the opening is seldom larger than 30 per cent of the vessel diameter, and where the design stress due to internal pressure is roughly one-fifth to one-fourth of the ultimate strength. In addition, the steels used in pressure vessel work are relatively ductile, and the yield strength is of the order of 50-60 per cent of the ultimate strength leaving a wide margin for ignorance. This design basis has been carried over into both high and low pressure pipe for steam, power and refinery process systems.

Modern high pressure pipe lines for the transmission of either oil or gas, owe their very existence to the economics of high strength pipe operated at stress levels much higher than those prevailing in other fields. Since the basis for design based on safety factors of 4 and 5 has been proved and time tested, we will limit our consideration in this paper to the basic aspects of the subject, and relate these to the types of materials and design stress levels common in pipe line work. The following brief comments will illustrate the major points of differences in the general conditions that form the framework for the discussion.

As previously mentioned, steam and oil refinery piping is essentially limited to the use of materials that are rated as ductile and whose yield strength is usually 60 per cent of the ultimate strength. The most common grades are covered by ASTM Specification A53, A135, A106 and API 5L. By contrast the majority of the tonnage used in high pressure pipe lines takes the form of cold expanded pipe, whose ductility is lower than that of the other material, by reason of cold expansion, and whose ratio of yield strength to ultimate strength is very much higher. In addition, wall thickness is usually established on the basis of a design stress level ranging from 60-72 per cent of the minimum specified yield strength using the Barlow formula.

Chart A presents graphically the margins for ignorance or for stress raisers that are inherent in the different types of construction and should be studied carefully. The discussion of branch connections is applicable to new construction as well as connections made to existing systems, but in considering branches made to existing systems under full operating pressure (and with gas or oil flowing in the line), the hazards are obviously magnified and the critical need for attention to design and construction procedures needs no further emphasis. These connections, made to systems under pressure, are commonly called hot taps.

The introduction of a branch line disturbs the symmetry of the pipe section and creates a condition of localized high stress level. In addition to this,

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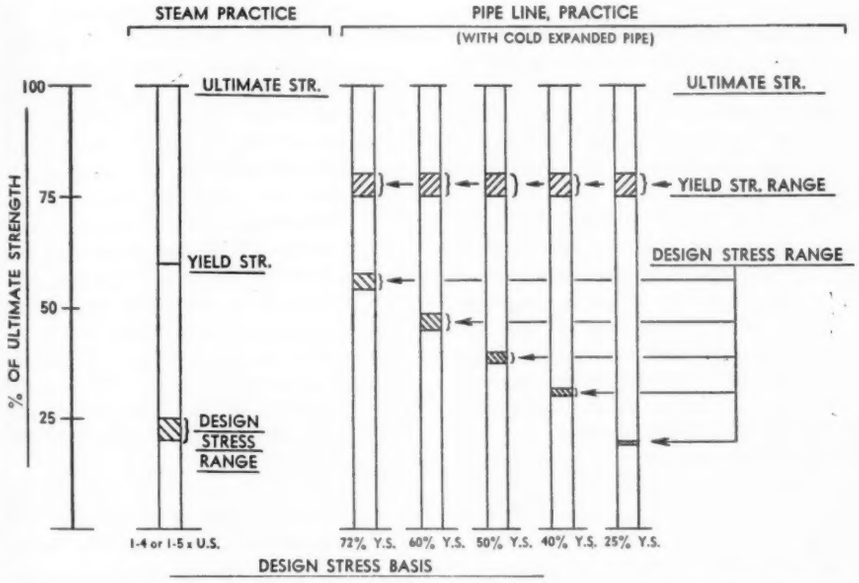

CHART A. COMPARISON of margins available at various design levels where design stress due to internal pressure is calculated by the Barlow formula and expressed as a percentage of the minimum specified yield strength of the pipe.

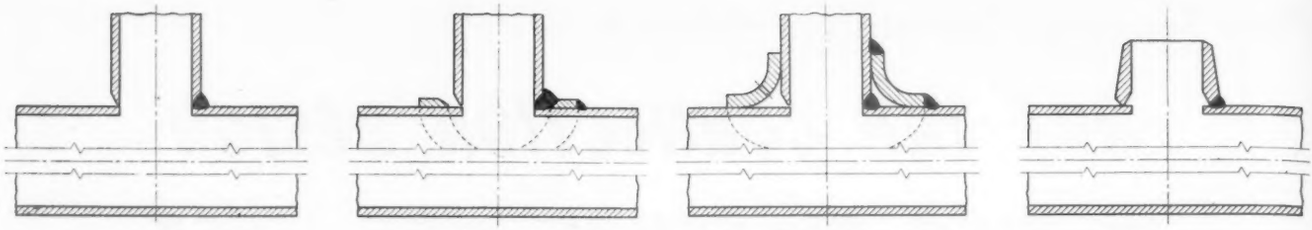

FIG. 1. HOT TAP Reinforcements — Local reinforcement types. Types commonly used where: Design stress $\leq$ 50 per cent of the yield strength and branch diameter $\leq$ 50 per cent of run diameter.

the forces acting on the internal area of the branch pipe exert an additional external loading, tending to pull the branch out of the main run. The second factor, while not significant in very small connections, can be increasingly important as the diameter of the branch increases in size with relation to the diameter of the run pipe. The result is that as the diameter of the branch increases, the need for careful design increases rapidly.

In addition to the two factors just mentioned, the bending loads caused by differential movements between run and branch, unsupported weight, and other similar causes, can be, and frequently are, of the same order of magnitude as the stress due to internal pressure. Wherever vibration is present, a still further design factor is introduced, and requires evaluation.

Remembering that there are three basic sources of stress around the branch connection, it is particularly significant that the ASME Boiler Code rules are based upon an evaluation of only the first of these three major forces and are restricted in their application to openings approximately 30 per cent of the run diameter or smaller. The pressure vessel codes recognize that special attention must be given to openings which exceed one-third of the vessel or pipe diameter and although detailed instructions are not set forth, paragraph UA-7 of the ASME Code for unfired pressure vessels attempts to lead the designer in the direction of safety.

Even with the best practical design proportions, it is necessary to accept stress concentrations, around branch connections of the order of 150 to 160 per cent of the hoop stress in the adjacent pipe due to pressure. In addition, it will be seen that wherever localized types of added reinforcement are employed, the stress condition close to the inside of the branch has been materially improved, but a new bending stress has been introduced along the circumferential axis. This bending stress usually has its maximum value just beyond the toe weld of the pad or saddle, and occurs in a direction that makes this additive to the hoop stress. This bending is created by the relatively greater stiffness through the reinforced branch section, so that when the pressure is applied this section will not expand at the same rate as the uncut pipe and a flat spot results.

It is possible to eliminate this bending moment by a proper proportioning of the added reinforcement, concentrating the bulk of the metal near the inside edge of the branch and contouring it.

It is the authors' opinion that high pressure design, particularly when coupled with the use of high strength pipe, should be based on the following approaches:

(1) Accept the existence of stress raisers around all branch connections of the order of 150 to 160 per cent.

(2) Reduce the basic stress level in the branch area by increasing the wall thickness in the run. This can be done by using properly designed tees, by using a heavier wall pipe thickness at the branch location or by a complete encirclement type of reinforcement applied to an existing line.

By doing this, the stress concentrations become additive to a lower basic stress and the combined stresses are kept below the yield strength of the material at operating and test conditions.

(3) Employ designs which utilize the principle of proper placement and distribution of reinforcing metal.

(4) Avoid localized forms of reinforcement, such as pads, saddles, etc., wherever the diameter of the branch exceeds approximately 25 per cent of the run diameter and the design stress due to internal pressure exceeds 50 per cent of the minimum specified yield strength.

Obviously the most practical method of achieving these goals is to use properly contoured forged tees of proven design for branch connections 50 per cent or greater of the run diameter on new construction.

Hot tap connection, however, is made to an existing line under pressure, and we must turn our attention to the application of basic terms of practical types of reinforcement that can be applied to operating lines. In this respect, the following general recommendations are offered:

a. The area of reinforcement in the finished construction must meet the rules for reinforcement of openings contained in the Code for Pressure Piping, or the ASME Code for Unfired Pressure Vessels. This latter Code is introduced because it has been recognized by the Code for Pressure Piping Committee that the present area requirements are in serious need of revision. The contemplated revisions would restrict reinforcing values in the branch pipe to the thickness in excess of that required for pressure and, also, restrict the length along the branch pipe which may be considered as having reinforcing value. It is expected that the revisions to the Piping Code will bring those requirements into agreement with the ASME Code for Unfired Pressure Vessels.

b. Wherever possible, provide reinforcement by increasing the thickness of the run in preference to pads of any type. In hot tap connections this can be most effectively done by providing a reinforcing member that completely encircles the run pipe.

c. Increase the thickness of the branch pipe. This provides reinforcement at the best location closest to the inner edge and also provides a reduction in bending stresses due to relative movement of inter-connected lines.

d. Proportion the fillet welds at the junction of the weld and branch in relation to the thickness of the pads welded.

e. Use all possible precaution, through welding procedures and techniques aimed at the avoidance of cracks, *unfused areas*, or sharp corners.

f. Whenever pads, saddles, or complete encirclement members are

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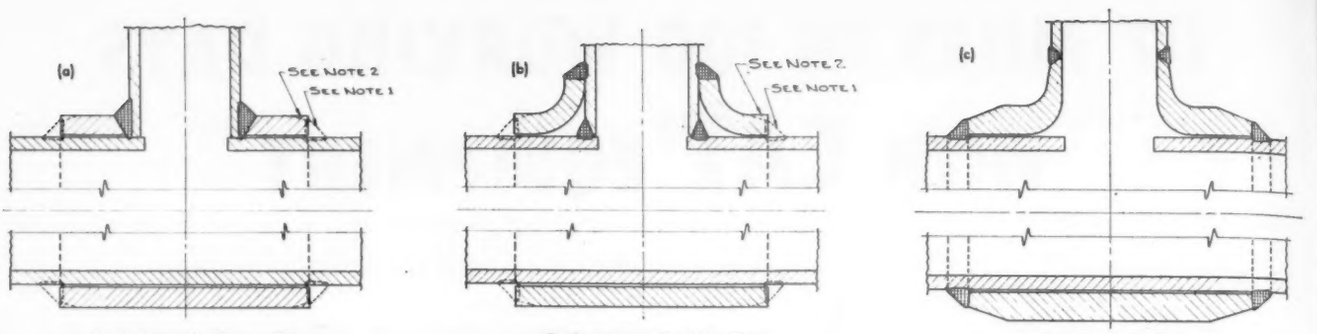

Encirclement Sleeve Type

INSTALLATION PROCEDURE — Step 1. Apply complete encirclement, clamp externally to provide a snug fit around run and make longitudinal welds. Step 2. Line up branch and tack lightly. Step 3. Weld branch and reinforcement, making certain the welding penetrates into the run pipe but only enough to provide an effective seal. Step 4. Girth welds at ends of sleeve are optional. Step 5. Make hot tap.

Encirclement Saddle Type

INSTALLATION PROCEUDRE — Step 1. Line up and weld branch to run. Step 2. Place split hot tap saddle around the branch pipe and clamp tight. In this type the identical halves are split through the branch. Step 3. Weld the longitudinal seams. Step 4. Weld the top of the saddle to the branch. Step 5. Girth welds at the ends of the split encirclement saddle are optional. Step 6. Make hot tap.

Hot Tap Fitting

INSTALLATION PROCEDURE — Step 1. Apply the hot tap fitting to proper location. Step 2. If branch is vertical, clamp in place and make longitudinal welds. If branch is horizontal, make one longitudinal weld in downhand position, loosen clamps, rotate branch to horizontal position, reclamp, make top longitudinal weld. Step 3. Make roundabout fillet welds. Step 4. Make hot tap.

FIG. 2. HOT TAP reinforcements—complete encirclement types. Types recommended for use where: design stress $>$ 50 per cent of the yield strength and/or branch diameter $>$ 50 per cent of run diameter.
Note 1. The fillet weld at this location is considered optional but is recommended. Note 2. If a fillet weld is used, it is recommended that the thickness of the reinforcing member should have an end thickness equal to the thickness of the run pipe and the member tapered to this thickness.

used the thickness of these members should be contoured at their outer edges so that the leg dimension of the outer fillet weld is equal to the thickness of the run pipe. This is particularly important where hot taps are being made on cold expanded pipe in order to control the volume heat during welding.

g. Some very competent pipe line operators have recommended that where pads are used, they should be of material comparable to Grade B pipe, since underbead cracking has been encountered in many instances where high strength material has been used for reinforcement.

h. Gussets are not recognized as having any reinforcing value, but they may be used as stiffeners where branch connections are subject to vibration. When gussets are used, the length of the complete encirclement member should be increased and the gusset should be welded to the encirclement member and not directly to the pipe.

i. Regardless of the design stress level or the type of reinforcement employed, it is recommended that the diameter of hot tap connections should not exceed two-thirds of the run pipe diameter, and preferably not exceed 60 per cent.

j. When the design stress level exceeds 50 per cent of the yield strength and the hot tap diameter exceeds 50 per cent of the run diameter, the complete encirclement type of reinforcement is deemed to be virtually mandatory and the installation should be such that the reinforcing encirclement should be securely welded in place before the stub (branch) is welded to the run pipe.

k. The hazards incident to welding the stub (branch) to relatively thin, highly stressed systems, combined with the near impossibility of obtaining fully penetrated welds at this most critical point, caused the author's company to develop a hot tap connection which embodies the principles of complete encirclement, full provision for stress concentration, and external loading; and which, at the same time, eliminates the stub weld into run pipe.

l. It is also recommended that hot tap connections should only be made by crews that have been especially trained under procedures that have been established by competent mechanical and welding engineers.

Fig. 1 illustrates various types of attachment that are commonly used on pipe lines where the design stress is equal to, or less than 50 per cent of the yield strength of the pipe and the branch diameter is 60 per cent or less of the run diameter.

Fig. 2 illustrates different types of complete encirclement reinforcement. The type shown in Fig. 2(a) is based on the utilization of either plate or pipe which has been split longitudinally to make assembly possible. As shown, the encirclement reinforcement is first welded in place. Next, the square cut stub is positioned, followed by welding the stub and reinforcement with a minimum amount of penetration into the pipe. It is difficult to evaluate all of the factors, but it is the author's opinion that the use of this should be limited to lines that are operating at 50 per cent or less of the yield strength of the pipe, and whenever space conditions permit, a weld between stub and pipe should be made on the inside junction to avoid the unfused area between the stub and the pipe which is inherent in the design unless this is done.

In Fig. 2(b), an encirclement saddle type reinforcement is illustrated. This type might be furnished as identical half sections, in which case, one longitudinal weld would be made at the crotch section for the purpose of joining the two halves. This type might also be furnished with the crotch section in one half, and the other section, a half cylinder. This latter type of splitting would remove the location of longitudinal welds from the highly stressed area around the crotch. The use of this type makes it necessary to weld the stub to the run before the complete encirclement has been applied. The authors feel that this exposes the workman to an unnecessary hazard during installation, although once the installation has been completed, the finished construction should prove satisfactory.

As in the case of Fig. 2(a), it is recommended that an inside weld between stub and pipe is desirable, if it can be done.

In both 2(a) and 2(b), the encirclement reinforcement is designed on the presumption that the run of pipe is carrying its normal load. * * *

☆ ☆ ☆

Horsepower necessary to drive the pumps in three principal stations of the "biggest inch" pipe line in North America, located in Texas, is equal to the power generated by five of the locomotives that pull the "Twentieth Century Limited" from New York to Chicago.

Pipe Line Application of Wire and Cable

Cable insulations of many types are now available; uses depend on wiring location, special conditions

R. C. GRAHAM

THE basic needs regarding cable insulations and wiring are much the same in the pipe line as in any other industry—lower costs, reduced dimensions, easier installation, improved performance, and longer life. The ways and means in achieving these needs, however, sometimes presents an entirely different problem than for other industries. Most cable manufacturers agree that pipe line service conditions are one of the severest of all cable applications. This situation requires unusually careful attention and selection of cable materials, properties, and design.

A brief consideration of the purpose of the cable insulation and its nonmetallic coverings may be helpful. The main function of the insulation or dielectric is to provide safe and durable electrical insulating value. The words "safe" and "durable" mean that it should possess adequate resistance to any deteriorating influences on its electrical insulating value that it may be exposed to during its normal life. Factors such as resistance to water and heat aging are highly desirable insulation characteristics if electrical stability is to be maintained. The resistance to other external influences such as weathering or sunlight, flame, oils, acids, alkalis, solvents and the like, may be, and usually are, provided by the insulation covering unless the inherent properties of the insulation itself preclude the need for further protection.

Primary function of the insulation covering is to provide the necessary degree of chemical or physical protection not already provided by the insulation. The insulation covering is also intended to protect the insulation from mechanical abuses incidental to operation and, principally, installation. Such coverings may be in the form of braids or sheaths (jackets), although the use of cotton braided cable coverings with their subsequent deterioration and rotting should now be a thing of the past with the modern synthetic sheathing and fibre materials available.

The Author

R. C. Graham is chief engineer for Rome Cable Corporation, Rome, New York. Since his graduation as an electrical engineer from Union College, Schenectady, New York, Graham has been associated with the wire and cable industry for more than 20 years in various technical capacities involving production, research, and product engineering and application. In his present capacity, he has been in daily contact with cable installations and problems — particularly those associated with the pipe line, petroleum and chemical industries. Graham has been a member of several government and industry committees including AIEE, IRE, PESA, IPCEA, IAEI and others. He is the author of many technical papers pertaining to wire and cable design, development, and application.

Insulating and sheathing materials to be reviewed may be classified as either thermosetting or thermoplastic. First to be considered is the thermosetting group, of which rubber or its synthetic counterpart, is probably the most familiar material.

Thermosetting Materials

Insofar as pipe line wiring jobs are concerned there are now relatively few insulating compounds that would be of special significance in spite of a multitude of trade names. The first of these is a moderately low cost, general purpose compound developed since the wartime advent of Buna S synthetic rubber and possessing the dual feature of good resistance to both heat and water—it is suitable for 75 C temperature rating and for use in wet locations. It is sometimes referred to as a combined RH and RW insulation and when used under an appropriate covering, can be safely recommended for nearly any 600 v a-c power circuit wiring application. It is especially suitable for secondaries and underground services.

Another useful but slightly higher in cost rubber insulation is the so-called oil-base ozone-resistant type of compound whose dominant constituent is a vulcanized vegetable oil. This insulation also possesses excellent heat and moisture resistant properties and may be rated at 75 C. Long experience has indicated that this high dielectric strength and corona-resistant compound may be safely used as power cable insulation up through 15 kv and possibly higher.

Butyl synthetic rubber has within recent years been introduced as cable insulation but long time performance records are not yet available. Indications are, however, that it may be recommended for similar ozone-resistant rubber compound applications. Industry specifications for such a compound recently have been established.

Performance of these rubber insulations in most applications would be short-lived if they were not protected adequately against the various exposed elements and reagents. The best known non-metallic sheathing material, Polychloroprene (Neoprene) is now almost universally accepted for this important application since it conveniently provides the desired functions of a sheath. Electrically, most Neoprene compounds are relatively poor, but their genuine toughness and resistance to abuse plus good heat, flame, and sunlight resistance, qualify their use as non-metallic protective sheaths. Neoprene is also resistant to low concentrations of chemical reagents at normal temperatures. However, principal dependence for moisture resistance must be placed on the insulation proper. Neither does Neoprene possess adequate resistance to severe gasoline or oil conditions, since it may be permeated by these fluids and associated vapors. For most general purpose wiring jobs, inside, underground or over-

EXCLUSIVE

head, this material makes a good protective sheath for the rubber insulation.

The newest and, right now, the most expensive thermosetting insulation, is so-called "Silastic" or silicone rubber. This recently developed material possesses many interesting properties that will undobutedly find certain applications in the petroleum and pipe line industry where excessive heat is a problem. Its chief virtue is its ability to operate over a very wide temperature range from —55 C to +150 C. A problem exists in finding some tough non-metallic protective covering other than a glass fiber or asbestos braid that will be able to perform over a similar temperature range. Of course, a lead sheath provides a suitable metallic covering.

Thermoplastic Materials

The best known and most widely used thermoplastic material is Polyvinyl Chloride or its copolymer with vinylacetate—let us call it PVC. This is the material that has been used as insulation on Types T and TW building wires and, so far, has consisted of a compound mixture of resin, liquid monomeric plasticizers, fillers, and pigments. PVC has so many virtues that it may serve as a combined insulation and sheath in itself—this means simplicity, low cost, small dimensions, easy installation, etc. PVC has reasonably good electrical characteristics but its use as power cable insulation is generally limited to 600 v a-c.

It lends itself particularly well to pipe line and refinery wiring because of its inherent resistance to flame, sunlight and weather, inorganic acids, oils, and many chemical reagents—even excelling Polychloroprene in these latter respects. Many manufacturers add a factory applied surface lubricant that greatly reduces pulling tensions. Such insulated cables may be used for almost any type of indoor or conduit wiring and a few types of outdoor wiring. It is being successfully used directly in the earth by several utilities for street lighting and other applications.

A recent development in PVC compounds has been accomplished in which poly-ester type plasticizers have been substituted for the usual monomeric plasticizers, resulting in certain performance improvements of special interest to your industries, since it will mean added resistance to oil, gasoline, and other chemicals, plus increased resistance to heat and deformation.

The next thermoplastic material in popularity is Polyethylene, which is now substantially equivalent in cost to PVC. Polyethylene, a pure hydrocarbon resin (not a compound), has many advantages to qualify it for cable insulation or sheaths for the oil industry. Its electrical properties, resistance to moisture, and cold temperature characteristics are superior to any other now regularly available non-metallic cable covering.

Being thermoplastic it is subject to appreciable heat deformation at or above its melting point of 105 C. However, there is practically no heat deformation up to 90 C, and is superior to PVC in this respect. If the circuit is to be subjected to frequent or heavy uncontrollable overloads, Polyethylene should not be used, although it is entirely satisfactory in this respect at its rated maximum temperature (75 C) or lower. Polyethylene is resistant to weather, most oils up to temperatures of 50 C and most solvents (not aromatics). Because of its remarkable moisture resistance and low permeability constant, it is an excellent choice for any d-c circuit insulation where moisture may be present.

Results of a research under way in Rome Cable Laboratory show Polyethylene to be outstanding over all other insulations when subjected to d-c moisture test. Conventional Polyethylene burns readily—but no more so than any ordinary rubber compound, so that this characteristic may or may not be objectionable. Flame-resistant Polyethylene compounds have been recently developed which will correct this property. Polyethylene is considered satisfactory for installation indoors, overhead, or in the earth. Industry specifications for Polyethylene insulated cables are now available.

Nylon thermoplastic is used either as

Pipe Line Applications of Wire and Cable
Brief suggestions for cost savings and special applications

Pumping Stations

Motors requiring a distribution voltage of 1200 are frequently required. Although not generally listed in manufacturers' catalogs, there is an IPCEA-ASTM rating classification of 2000v that would be appropriate for such wiring. Therefore, a 2000-volt rated cable consisting of ozone-resistant insulation with an outer Neoprene sheath — either as single or multiple conductor assembly is suggested.

Cathodic Protection

For underground cable connections between the electrodes and pipe line, a satisfactory and economical solution is heavy wall TW. A satisfactory alternate type is so-called type RR underground cable rated at 600 v. Either may be buried directly in the ground.

Pipe Line Telephone

A most economical and satisfactory multi-paired cable design utilizing thin walls of Polyethylene, shielding, and overall synthetic sheath has been developed for either overhead or underground application.

Pulling Compounds

For Neoprene sheathed cables a lubricant consisting of soap flakes and water has been found very effective. For TW type insulations a surface lubricant is ordinarily applied at the factory. However, paraffin or "Albany" grease serves where further lubrication may be needed. Polyethylene is practically self-lubricating — ordinary water should provide adequate lubrication for most jobs.

Direct Buried Cables

Install at least 18 in. below the ground. If unshielded, keep cables spaced a few inches in the trench and a bare counterpoise wire installed in the same trench will provide some lightning protection.

Shielded Power Cables

Where expense is considered too great, consider either conventional lead sheathed or thermoplastic jackets (instead of Neoprene) over the shield.

Large Conductors

Whenever space permits, the paralleling of conductors is good engineering and economical. One large company has reported they try to limit any maximum conductor size to 500 MCM. For example, substitution of paralleled 300 MCM Type RH conductors will provide the same current-carrying capacity as single conductor 1000 MCM type RH — at a cost saving (cable) of 25 per cent and a further substantial saving of copper.

Multi versus Single Conductor Power Cable

Wherever terminal and raceway space permits, three single conductor power cables have certain technical and economic advantages over a three conductor cable. On most 600 volt sizes this means at least a 30 per cent saving in cable cost plus easier splicing, repairing, fault location, etc., for the single conductor cable which, incidentally, also incorporates full sheath protection throughout the circuit length.

Cable Specifications

Wherever possible it is recommended that standard industry specifications be adhered to. Special requirements or "trick" tests usually means increased costs, restricted supply, and delivery delays.

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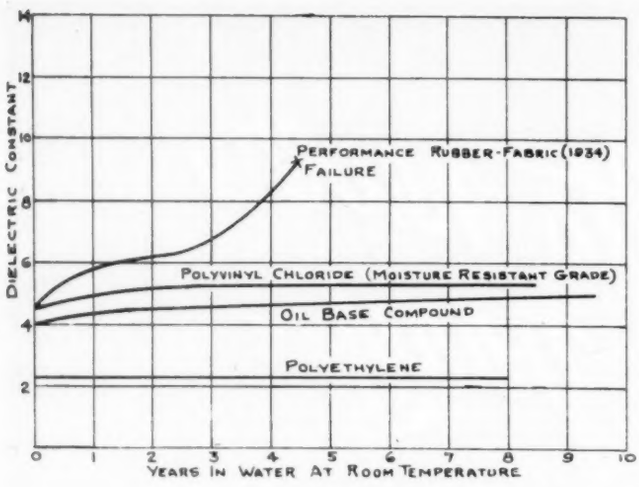

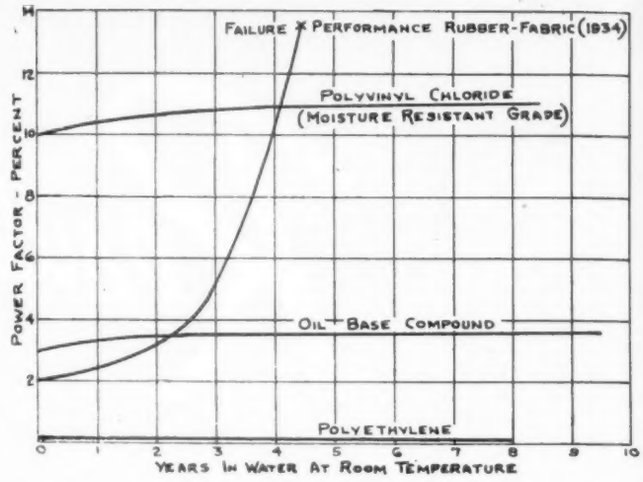

FIGS. 1 AND 2. LONG time electrical data describing moisture resistance of cable insulation.

an extruded sheathing material or as a fabric for braid coverings. It is relatively high in cost and its proposed end uses should be carefully reviewed before deciding upon its application. Its primary feature as a cable covering is its unusually high resistance to mechanical abrasion and crushing. So far, Nylon has not been used for primary insulation due to inherent poor electrical properties and moisture resistance.

Polytetraflourethylene (Teflon) and flourinated ethylene (Flourothene and Kel-F) are under development as cable insulations. Although present costs are prohibitive, the anticipated advantages of these materials will undoubtedly find many applications in the future. Their almost complete resistance to all solvents, chemicals, flame, water, etc., added to their excellent electrical and heat characteristics certainly present an attractive picture for hazardous wiring jobs.

One of the major enemies of cable insulation in the past has been water and this problem has undoubtedly precluded use in many underground or wet applications. Figs. 1 and 2, however, present data on long-time tests that illustrate the progress that has been made in making our modern insulations substantially waterproof so that we can now confidently select a proper insulation without a lead sheath for wet locations.

Laboratory Testing

Our knowledge and best uses for these materials are mainly obtained from intelligent testing and development of the right kind of tests has been a problem in itself. Insofar as nonmetallic sheathed cable is concerned it has been found that resistance to moisture is probably the greatest determining factor for a successful service life. Accordingly, a large part of laboratory research over the past 15 years has been devoted to development of a suitable test to prove whether or not a cable should be used in a wet location.

It has been long since determined that it is not necessarily a question of how much water is absorbed, but of much greater significance is the location of the absorbed water in the insulation, and this can only be established by electrical test methods. A test has now been developed to determine the electrical stability of insulations in water and, recently, has been adopted as a Standard by ASTM and IPCEA.

Another somewhat new and highly useful test for cables rated at 3000 v and higher is called the corona-level test. This test serves as a vital control of quality by measuring the start of internal ionization within the cable. Since loose insulation or shields, voids, abnormal porosity, etc., might cause destructive ionization discharge at the operating voltage, it is the object of the corona-level test to detect this condition and thus reduce another failure hazard.

Cable Design and Selection

Probably the best known design utilizes a combination having about 15 years experience and consisting of a good rubber insulation with an overall Neoprene sheath. The features of such a cable as compared for instance, with a lead sheathed cable are simplicity which aids in splicing, freedom from electrolysis, light weight, low cost, and a general-purpose end use either over-

Suggested safe practice for pipe line wiring.

	General purpose applications		Special conditions present						
Location of wiring	0–600 Volts a/c power	Over 600 volts a/c power	Direct current	Dilute alkalis	Dilute organic acids	Dilute inorganic acids except nitric	Oils	Gasoline or organic solvent except ketones	Low temperatures
Outside-overhead open wiring	Neoprene or polyethylene weatherproof wire.	Neoprene or polyethylene line wire.							Polyethylene weatherproof wire.
Cable (Outside-overhead open wiring)	Rubber-neoprene	Oil base rubber and neoprene or polyethylene	Polyethylene or oil base rubber and neoprene	Polyethylene or oil base rubber and neoprene	Polyethylene PVC or rubber and neoprene	PVC or rubber and neoprene	Lead sheath PVC buna n	Lead sheath polyethylene PVC buna n	Polyethylene natural rubber buna n sheath
Inside–conduit exposed aerial rack or tray	PVC or rubber and neoprene polyethylene.	Oil base rubber and neoprene or polyethylene.	Polyethylene or oil base rubber and neoprene.	Polyethylene or oil base rubber and neoprene.	Polyethylene rubber and neoprene	PVC or rubber and neoprene	PVC lead sheath or buna n.	Lead sheath polyethylene or rubber and neoprene PVC.	Polyethylene natural rubber buna n sheath.
Underground ducts.	PVC or rubber and neoprene.	Oil base rubber and neoprene or polyethylene.	Polyethylene or oil base rubber and neoprene.	Polyethylene or oil base rubber and neoprene.	Polyethylene rubber and neoprene.	PVC or rubber and neoprene.	PVC or lead sheath.	Lead sheath polyethylene or rubber and neoprene.	Polyethylene natural rubber buna n sheath.
Direct burial.	Rubber and neoprene or polyethylene.	Oil base rubber and neoprene or polyethylene.	Polyethylene or oil base rubber and neoprene.	Polyethylene or oil base rubber and neoprene	Polyethylene rubber and neoprene.	Rubber and neoprene.	Lead or special thermoplastic sheath.	Lead sheath polyethylene or rubber and neoprene.	Polyethylene natural rubber buna n sheath.

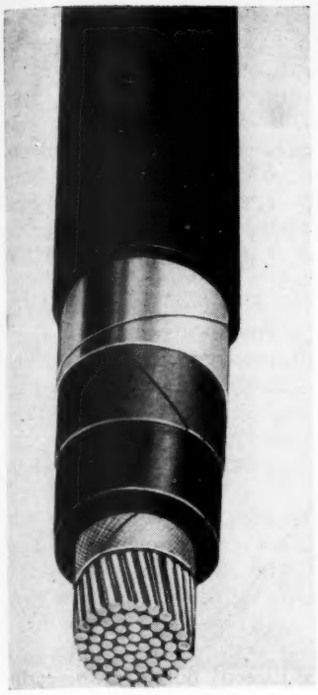

FIG. 3.

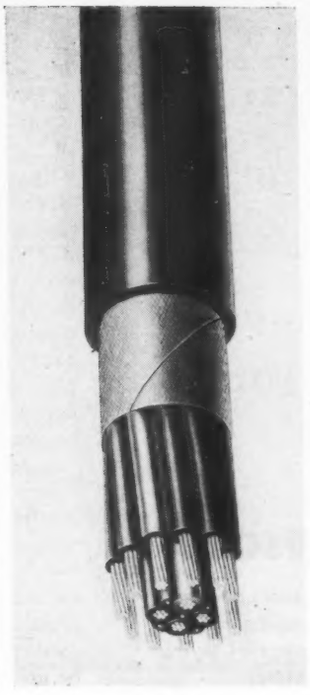

FIG. 4.

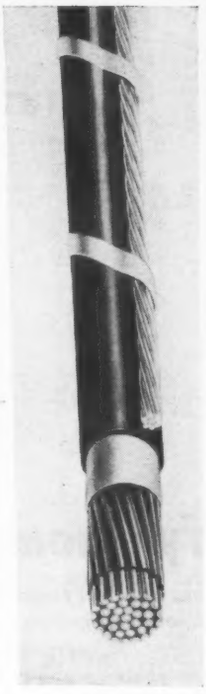

FIG. 5.

FIG. 3. 15 KV rated cable, ozone resistant insulation, metallic shielding, thermoplastic sheath.

FIG. 4. CONTROL cable — Polyethylene insulated, thermoplastic sheathed.

FIG. 5. AERIAL telemetering cable with factory applied messenger.

head, underground, or indoors. With modern grades of insulation such a cable is almost foolproof for most 600 v power applications. Experience has shown, however, that for certain installations involving severe oil or chemical exposure that a conventional lead sheathed or suitable thermoplastic design may be preferable.

When circuit voltages over 3000 are encountered it may be desirable to incorporate a metallic shield between the insulation and sheath for protection to personnel or to eliminate failure possibility from sheath leakage and discharge or from voltage surges. Where a shielded cable (Fig. 3) is advisable for electrical reasons and where there may be considerable exposure to oil or chemicals a more economical thermoplastic sheath instead of Neoprene is suggested. This would be especially true for buried installations near or exposed to the pipe line conditions.

For many 600 v applications especially lighting, machine wiring, branch circuits, etc., a TW or PVC insulated conductor has provided satisfactory and economical service—especially for the petroleum and chemical industries. Recent trends indicate that slightly heavier than standard TW walls of a special heat-resistant PVC compound are being successfully used in many locations including direct earth burial. Such PVC insulated conductors are not generally recommended for power circuit applications in excess of 600 v.

Polyethylene as insulation or sheath is gaining prominence rapidly and is already being used in the chemical industry for power cable insulation on cables rated up to 15 kv. The material is also ideal for low voltage d-c control circuit wiring as illustrated in Fig. 4. It is about the only satisfactory material available for high-frequency and telephone cable insulation on non-leaded designs. In fact, multi-paired telephone cables using Polyethylene have been manufactured for installation directly in the trench with the pipe line itself. Such cables are specially constructed or custom-built for the job. Similar telephone cables can be designed for overhead use.

Overhead cable versus open-wire construction is rapidly gaining in popularity mainly because of substantially improved appearance and protection from storm outages. Aerial cable construction initially costs somewhat more than open-wire, depending upon the operating voltage but compared with underground construction costs considerably less and offers similar advantages. Almost any type of power, control, or communication cable can be so constructed as to be adaptable for aerial construction by incorporation of

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★

HOT DOPE

Straight from the Kettle on PIPE PROTECTION

★

By Boyd Mayes

● Used to be an Old Timer named Josh who sat in a chair all day on the board floor in front of the general store in our home town. He'd tilt the chair back, close his eyes, and just rest all day. Josh saw more and rested more than anybody we ever knew. Somehow, just sitting still made all the folks think he was wise. He did pass out some pretty smart thoughts, at that. One time I asked him why he was always in such a good mood and he said: "Anybody who does his job well and likes what he is doing is happy. Take me for example. I just sit all day and rest—an' I enjoy it—but some folks can't even enjoy sittin' still."

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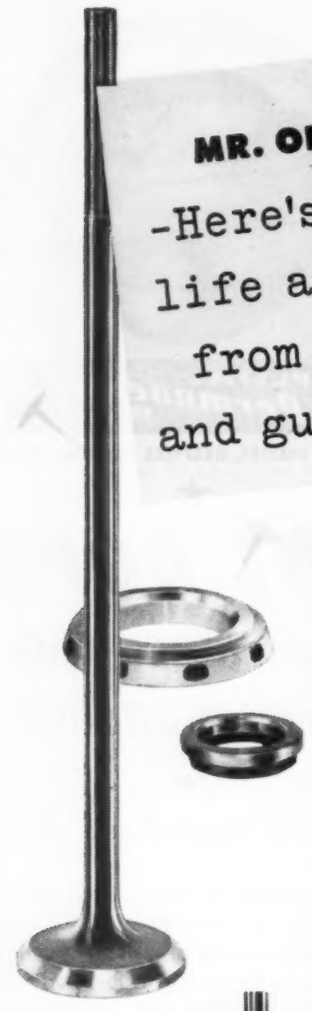

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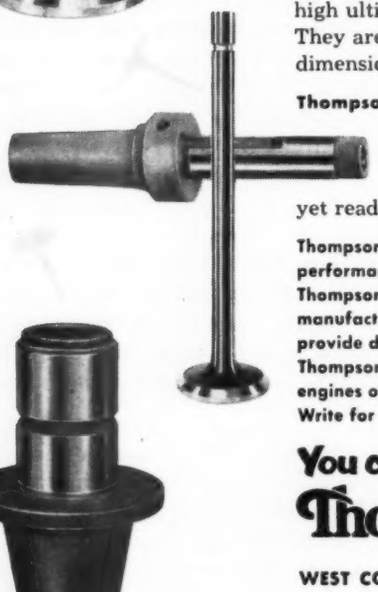

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built-in messengers (Fig. 5) at the cable factory or by the use of field assembled messengers.

For primary voltages up to 15 kv, aerial cable design generally consists of ozone-resistant rubber insulation with an overall corrosion-resistant shielding tape—or unshielded Neoprene jacketed designs for voltages up to 5000. For secondary 600 v construction, a simple cable design consisting either of Neoprene or Polyethylene insulated conductors wrapped around a bare neutral-messenger provides a simple, low cost arrangement. Standard hardware is available for any of these overhead designs.

Underground cable types generally utilize shielded, Neoprene or Thermoplastic sheathed, ozone-resistant rubber insulated conductors for voltages over 3000 (Fig. 3)—and either special thermoplastic or rubber insulated Neoprene jacketed type RR cable for 600 v applications. Any of these cables may be utilized directly buried in the earth.

Aluminum Conductors

The subject of aluminum conductors has been "on and off" for the past several years, depending upon metal availability and economics. For overhead applications involving weatherproof line wire or low voltage secondary distribution cables, the light weight and economic advantages of aluminum present such an attractive picture that its continued and extended use for such purposes seems assured. The only real problem has been the development of satisfactory connectors where good progress is rapidly being made.

For underground and other insulated cable applications the future of aluminum is somewhat doubtful. There are practically no technical advantages and the economics are deceiving. For example, the electrical equivalent in aluminum which is two AWG sizes larger than its copper equivalent means that where insulated cable is concerned an increased volume of insulation and coverings must be used. This added expense coupled with the necessity of larger raceways, more expensive connections, etc., may easily offset any apparent original savings in conductor metal particularly for voltages in excess of 600. Wherever space considerations are of importance, the use of aluminum may be almost prohibitive due to increased size.

Aluminum to copper connections in small branch circuit sizes of insulated conductors require special devices and skill that if not closely adhered to, might cause difficulty. The use of suitable compression type connectors on the larger feeder sizes has been satisfactorily established. * * *

A-frame carries Trans Mountain across chasm near Mount Robson.

Foothills slough at bottom of hill near Entwistle, Alberta.

P 605.

Canadian Pipelining--1953 Review

Canadian terrain, weather is big headache to contractors, many innovations necessary; operations experience still limited, new practices being developed, problems solved

LESLIE ORR ROWLAND

DURING 1953 very little progress was made in drawing any conclusions about operation of crude lines in Canada, while the operation of products lines had started so recently that no operating experience at all had been built up. The only comment that can be made on the Trans-Northern line and Imperial's Sarnia products line is that they operated with complete satisfaction in their first year.

The Interprovincial pipe line engineering staff has made studies of wax deposition, which were embodied in a paper presented by western division manager H. LeM. Stevens-Guille at a technical society meeting last spring. Curves of quantities of wax removed by scrapers run at regular intervals, usually more frequent in summer than in winter, show a consistently higher accumulation in warm weather. This was contrary to expectations, as summer operating temperature is about 50 F, contrasted with 30 F in winter. The possibility that more wax is deposited in the lease tanks in winter, thus accounting for smaller accumulation in the line, is not considered an adequate explanation, but no other definite conclusion has been reached.

The type of scraper used in this line is the leaf spring loaded wire brush having two rubber cups that are forced out to full pipe line diameter by pressure of the flowing oil, keeping to a minimum the slippage of oil past the scraper. No scraper has yet become jammed in a valve or elsewhere. It is expected to be some time before enough replacement will have been required to give any idea of the average scraper life.

Corrosion Under Study

Some progress was made in 1953 in dealing with corrosion problems presented by the use of Redwater line crude as diesel fuel for station pump engines. The oil is purified only to the extent of centrifuging and then passing it through filters packed with cellulose. Rapid corrosion of the ring seats in aluminum pistons is expected to be overcome by insertion of cast-iron ring seats. Experiments are being conducted with this method of treatment in the Gretna pumping station of Winnipeg Pipe Line Company, the affiliate that owns and operates the branch line to Winnipeg.

Housing Is Problem

Both the major crude oil pipe lines have a common problem of housing maintenance personnel, and this has involved capital outlay of several million dollars. Interprovincial provides houses for all station operators except at the three principal cities of Edmonton, Regina, and Superior. Oilers, however, are recruited from local residents as a public relations policy of local employment, and own their own homes in the towns or villages near the stations. The scattered settlement of the country through which both lines pass is a major problem for recruitment and accommodation of personnel.

The Trans Mountain company built 101 houses in 1953, for the accommodation of station and maintenance em-

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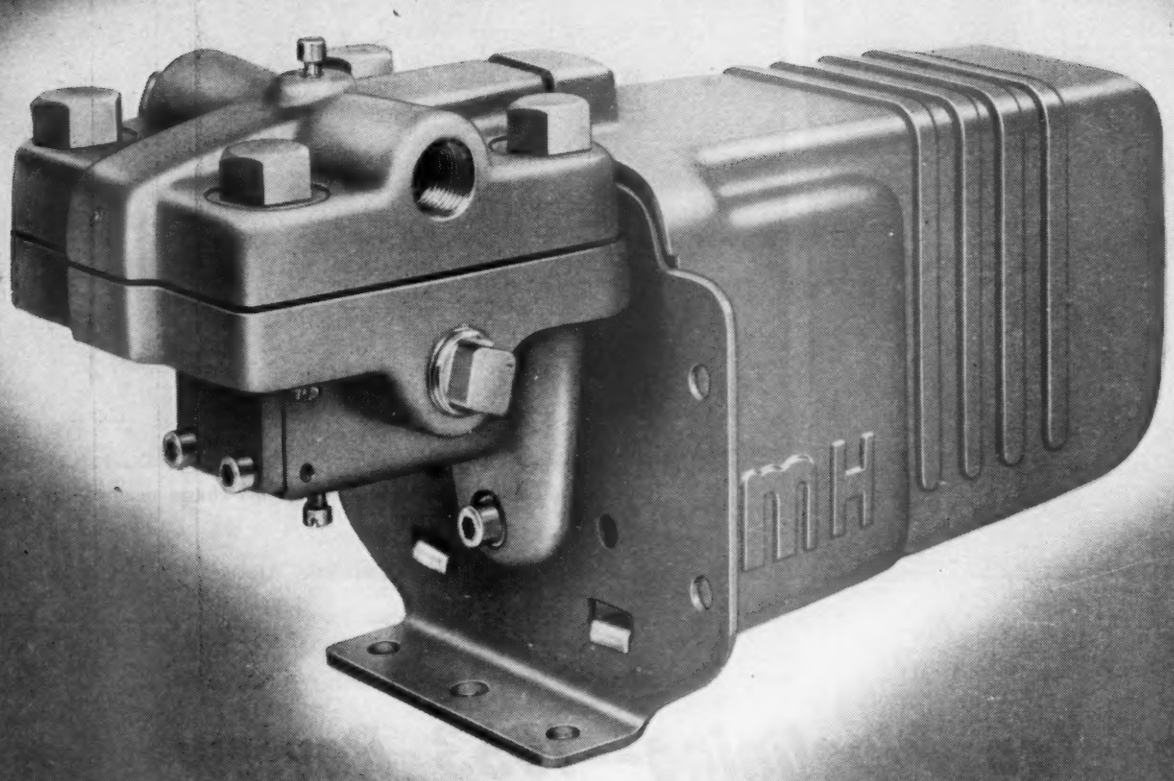

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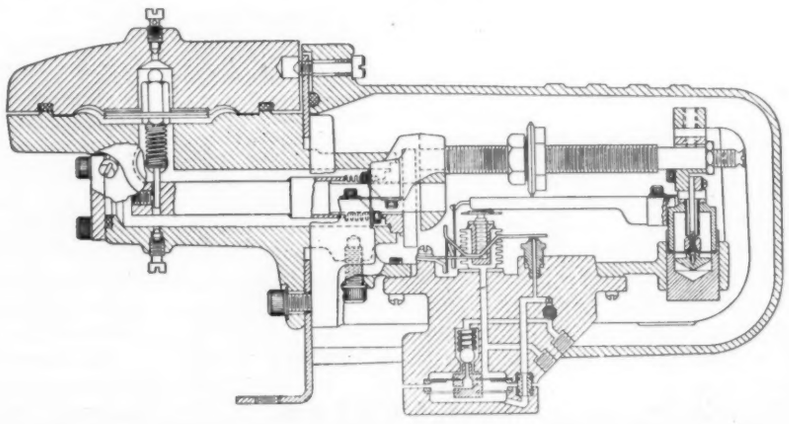

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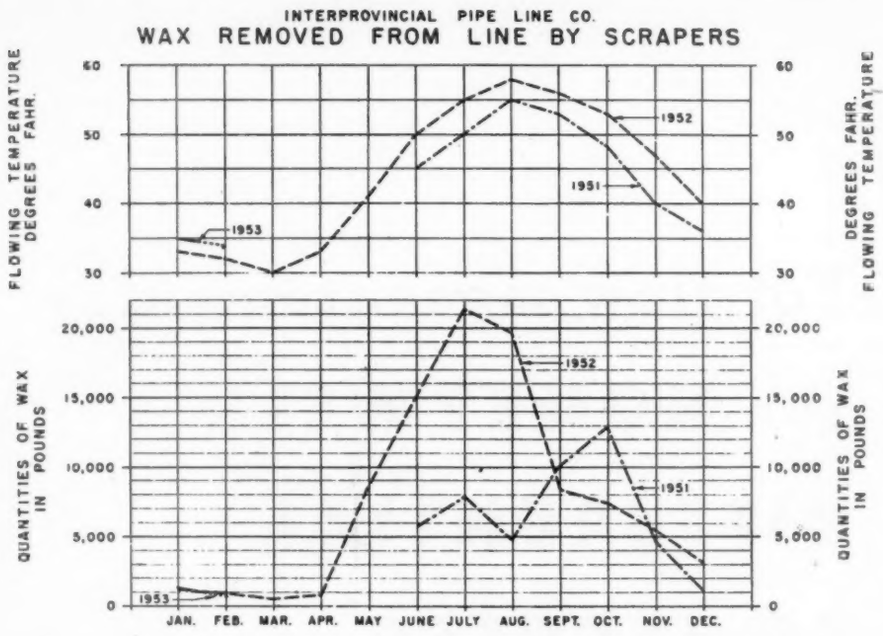

GRAPHICAL PRESENTATION of wax removal by scrapers from Interprovincial Pipe Line, 1950-1953 period.

ployees, at a cost of about $1,000,000, exclusive of landscaping and equipment.

Maintenance Adequate

Maintenance of the Interprovincial line has proved to be not troublesome, even in the severe prairie winters. Patrol by aircraft every week and maintenance and repair by five travelling gangs have been adequate. Scheduled preventive maintenance is expected to keep involuntary shutdowns to a minimum and to raise no unusual problems.

The Trans Mountain line, in its first winter of operation following commencement of terminal deliveries at the middle of October, is expected to meet with some maintenance problems that cannot be anticipated. Six maintenance headquarters points have been set up, at intervals of 90 to 140 miles, depending on accessibility of passable winter roads, which are not common in the Rocky Mountains. Crews are all equipped with a variety of four-wheel drive vehicles, including jeeps, power wagons, and 4-wheel drive trucks. Trial operation of snowmobiles, snow "cats" and muskeg "crawlers" is being carried out this winter, with the intention of gathering informative data on relative efficiency.

Three railway service units, consisting of a heavy duty flatcar and a combination sleeping-boarding car, have been purchased to transport heavy equipment when necessary. This heavy equipment comprises a track-type tractor and a ½-yard backhoe for each unit, which can be carried on heavy duty trailers towed by trucks into portions of the line accessible by road. About half the total length of the line, some 375 miles, can be reached by improved roads. Considering the average annual snowfall of 30 to 50 ft, occurring almost entirely in the parts not served by roads, considerable experience in the most difficult type of winter maintenance should be built up by next spring.

Scraper runs through the Trans Mountain line will also be at intervals of five to seven days, as it is handling the same type of high wax content crude as the Interprovincial line.

Hydrostatics Problem Solved

In designing the station equipment for the Trans Mountain line, a problem of hydrostatics was presented, which was solved by a combination of series and parallel arrangements of station pumping units, depending on terrain. For the high static head conditions to be encountered in the regions of steep gradients, at Edmonton input station, Blackpool and Kamloops, parallel arrangement is considered more economical, while series arrangement has been provided at Edson and will be installed at Jasper and Gainford when those stations are built.

The static lift out of Edmonton, when throughput reaches 120,000 bbl per day, will be about 45 per cent of the whole pumping head, while at Kamloops it will be 65 per cent. With the parallel arrangement, it is estimated that flows up to 75,000 bbl daily can be handled with a single unit. All stations have been designed with three units, of which only one will be required for initial operation, the second coming in above 75,000 rate and the third being a standby. Operating experience is, of course, too limited to draw any conclusions about the performance of this combined arrangement.

Pressure Limiting Stations

An interesting feature of the construction design for Trans Mountain was the saving of $5,000,000 in capital cost by installing two pressure-limiting stations, one at Vavenby, a point 165 miles west of and 2100 ft lower than the first peak over the Yellowhead Pass (elevation 3720 ft), and the other (a pressure relief station) at Hope, 30 miles west of the 3760 ft Coquihalla Pass summit, at elevation 210 ft. The Vavenby station has an automatic valve that controls static head down-stream by a reduction of 650 ft to 2160 ft (considered a safe head) to the Thompson River crossing at Kamloops where elevation is only 1120 ft. The Hope station has a battery of relief valves that can spill a total of 100,000 bbl into tankage so that pressure in the downstream section of the line between Hope and the Burnaby terminal at Vancouver may be reduced to safe limits in the case of accidental closing of a valve against the main line flow. The saving was effected through the reduction of pipe wall thickness that would have had to be provided otherwise to withstand high pressure in event of accidental shutoff in low sections.

Communications and Patrols

Communications on both the major pipe lines are by teletype and a combination of fixed and mobile radio, analysis of operating conditions in both cases dictating against the use of a microwave system. On the Trans Mountain line the tortuous route through the mountains would have required too many repeater station towers, and the absence of roads, coupled with the excessive snow fall, would have made maintenance of service continuity impracticable.

Aircraft patrol on the Interprovincial line has been thoroughly satisfactory, with two-way radio in the aircraft and also in each station. This enables the pilot to notify the nearest station without landing, in the event of any line trouble being noticed, and the station in turn can inform the Edmonton control office by teletype. A crew is then dispatched from the nearest location.

The Trans Mountain line makes use of teletype service leased from the railway company, connecting seven locations, but more extensive dependence is on the leased telephone circuit connecting 25 locations, and on the company-owned dual-frequency radio system, which comprises nine fixed stations and 25 mobile stations. The telephone system is used principally for dispatching and for emergency communication in the 250 miles of the

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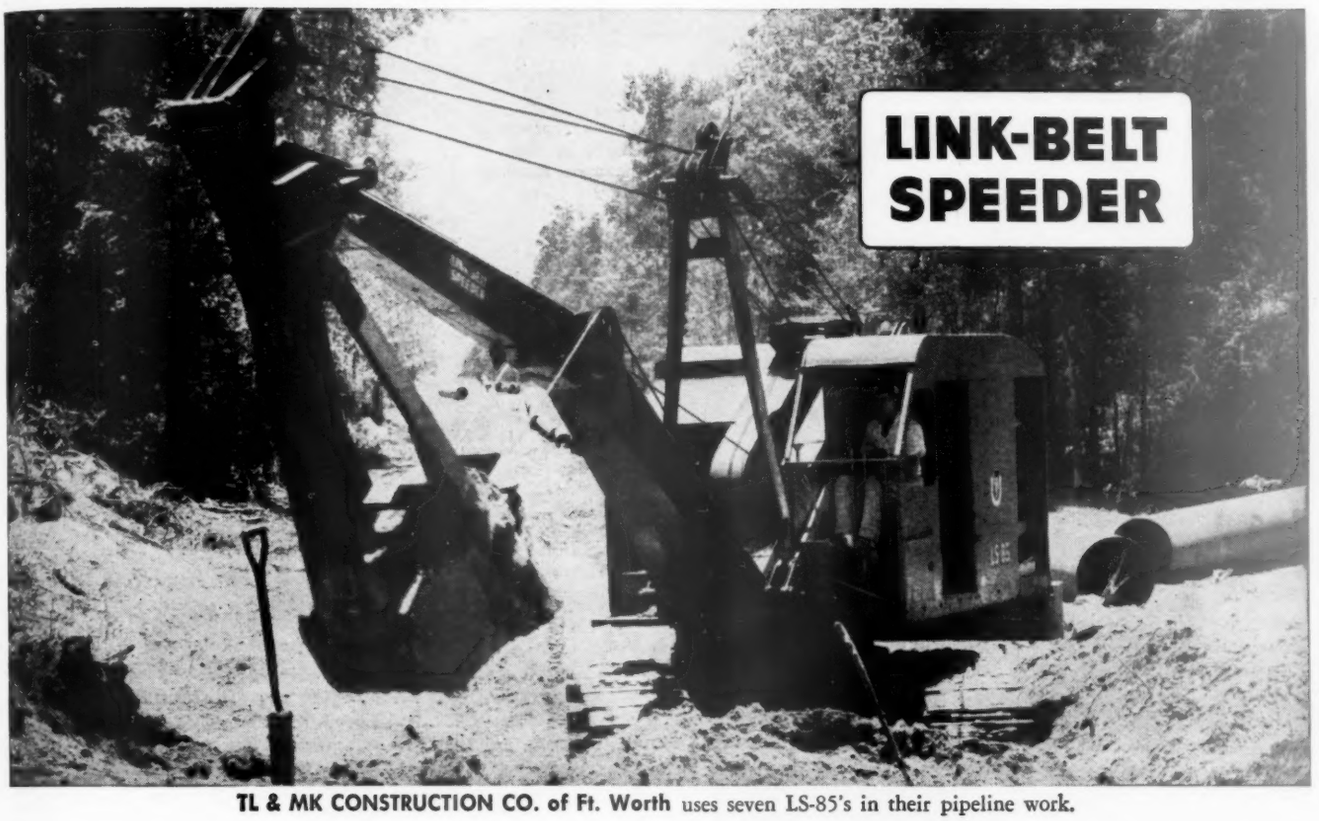

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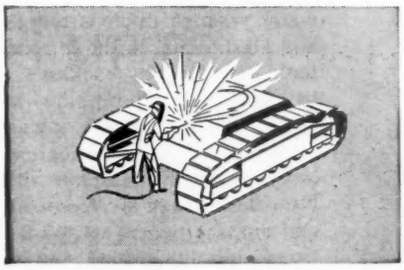

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Backhoes replace trenchers in the treacherous muskeg country.

Dope gang working on soft ground on Trans Mountain near Entwistle.

Close working quarters presented many problems on Trans Mountain.

line that has no public telephone service available.

An electronic tone-response ringing system, to be installed shortly, will supplement this system by permitting the ringing of all regularly connected instruments from the dispatcher's office and from Edmonton station.

The teletype service is operating initially on an experimental basis, so that results of this winter's operation probably will determine whether it is continued. It is used primarily for administrative messages and connects offices and stations only, but can be used in emergency if the telephone circuit fails. The fixed radio sets are designed for use in contacting maintenance personnel and ensuring continuity of dispatch communication, being located at terminals, stations and maintenance headquarters. Experience to date with the 2628 kc frequency (AM) has been that it is effective in piercing the mountain terrain. The VHF channel of 165.63 mgc (FM) is used for normal communication with and between vehicles, which also carry the AM equipment.

Efficient and economical communication can reasonably be considered as one of the major technical achievements on both the large crude oil pipe lines.

1953 Construction Experiences

The summer of 1953 proved the truth of a lesson learned by contractors who laid the Interprovincial pipe line in 1950—that prairie weather is unpredictable, not susceptible to long distance forecasting, and liable to impose high cost of construction through wet weather delays and the vagaries of a constantly shifting water table. From the driest spring on record, the prairie weather changed suddenly at the beginning of the construction period to the wettest summer since 1950, with the result that an average speed of no better than a mile a day was achieved during the entire loop job. In the mountains and the Alberta foothills, scarcely a day went by without some rain, causing the muskegs and bogs to remain full of water for the whole construction period so that it was literally possible to "lose" a whole spread by inability to get from the access roads to the right-of-way at times.

The Muskeg "Curse"

Canadian muskeg, the soft, water-saturated, spongy, mossy soil that gives way under any substantial weight and cannot be bottomed at less than 10 to 20 ft below the surface, was the greatest single headache for the contractors on the foothills and mountain sections of the Trans Mountain line in 1952 and 1953. This type of ground is variable, sometimes consisting of open water dotted with islands, and more often an apparently solid formation in which the water is not visible at ground level. It always leaves a canal of open water when a ditch is cut through it, and all ditching in the muskeg sections has to be done by backhoes supported by extensive rip-rapping and mats. Even with this support, it was common experience to have a backhoe roll over and sink several feet into the muskeg. No solution was arrived at in stringing and pipe laying, except to make up sections on solid ground and push them across the muskegs.

The distance of muskeg that had to be crossed in this manner varied from a few hundred feet to a maximum of 21,000 ft, and on the foothills section of the Trans Mountain line, consisting of about 81 miles, the proportion of muskeg terrain was 45 per cent. The Comstock-Midwestern Limited spread on this section met with eight solid miles of muskeg right at kick-off, and employed 120 men on rip-rapping for several days. Since long sections of pipe had to be skidded for muskeg crossings, this also involved the use of an exces-

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The 30-inch pipe line was started during July, 1953, and will be put into service the first part of 1954 . . . another pipe line conquest of rough terrain, desert, mountains and canyons.

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sive number of skids. Spread superintendent Denver L. Franklin used at least 50,000 skids on this section, buying them all from local sawmills, which, fortunately, are located at frequent intervals in this heavily timbered country.

Muskeg Vehicle Needed

No type of tracked vehicle such as the light equipment developed for use of oil exploration crews in muskeg regions has yet been invented for carrying the much heavier pipe line equipment. If any such type could be developed, it would undoubtedly cut both construction time and cost materially. Meanwhile, the experience gained in the hardest imaginable weather and ground conditions of the 1953 season can be applied to any future pipe laying in that region.

Congestion of the right-of-way is a persistent problem in making up extra sections for muskeg crossings. The heavy though small timber growth makes the cost of clearing extra right-of-way prohibitive, so the contractors resort to lining up these sections in the same part of the right-of-way already occupied with normal line construction. In many places clearance for tractors was no more than a few inches from the pipe.

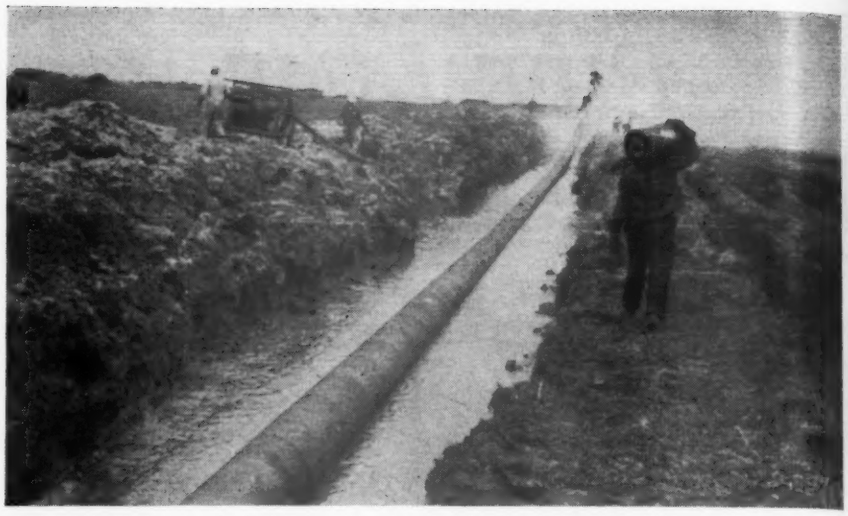
Not Many Roads

The foothills and mountains are not well served with roads for access to the right-of-way. Some hard surfaced highway is available, but the bulk of side roads are dirt, which become impassable quagmires in wet weather. Ruts and potholes up to three or four feet deep make vehicle movement very difficult, and even jeeps could be high-centered very easily when trying to straddle the ruts.

A large number of skids were pitched into the potholes in an effort to fill them up to ground level, as each successive vehicle passing over any side road would cut the ruts a little deeper in the soft ground. Time spent in getting men and trucks from living quarters to the right-of-way was a large element in this job.

In the prairie region, every wet year raises the water table and enlarges the sloughs and swamps in low ground to several times their dry cycle area. The terrain, which looks fairly regular and level from the air, contains a large proportion of these hazards that have to be detoured by ordinary vehicles and pose a considerable problem of encroachments beyond the right-of-way.

Conventional rotary ditchers bog down very easily and backhoes have to be run in for most of the swampy sections. Pipe laying is complicated by the difficulty of getting a solid footing for sideboom tractors, which have a habit of tipping over with the weight of the pipe as soon as they strike any soft ground. Tow-tractors were in common use on the prairie construction sections last summer, and pipe gang trucks almost invariably carried chains on all rear wheels.



Doping and lowering-in Interprovincial loop in Manitoba swamp.

All contractors operating in western Canada have adopted the practice of lowering in immediately after doping, in order to avoid the cost and time of skiding the pipe a second time. This method is also considered to reduce the risk of damage to the wrap through a second handling, and is favored by the line owners. Slack loops are left to settle into place over night.

Trans Mountain Sets Trend

Completion of Trans Mountain was one of the major accomplishments of the pipe line construction industry. There have been pipe lines laid over more river crossings, up and down steeper grades, around sharper side bends, with more mileage of rock, and with higher altitudes to cross, but never before have so many of these conditions and so much of each type been combined on a single job. The experience gained in the summer of 1952, when the right-of-way was cleared, showed contractors the value of heavier equipment in bulldozer blades than they had been accustomed to use. The Coquihalla section, laid in the summer of 1953, contained some of the toughest mountain terrain in pipelining history, including the Coquihalla jumpoff with its 38-deg slope and the Iago jumpoff with a slope of 47½ degs, each for a distance of 1000 ft or more. Fortunately this section of the line was not typical of the mountain regions, which generally provided better footing for vehicles and machines than the foothills muskeg or the prairie sloughs. The Trans Mountain construction has set a pattern for laying all future Rocky Mountain region pipe lines.

Specialized and streamlined pipe gang and firing line organization was conspicuous in the line-up and welding. On most spreads, one pipe gang truck was used for the stringer bead and another for the hot pass. Firing line welders were worked in tandem, each machine being hauled by a light tractor to the front of the line as the capping welds were completed. Welding machines were mostly mounted on rubber-tired buggies rather than on skids, for easier hauling. Internal line-up clamps were used almost universally except for tie-ins where external clamps must be used.

Short Season Is Strain

No revolutionary types of equipment were developed for Canadian use, but all equipment was subjected to the strain of speeding a job through the short five-month Canadian construction season (shortened still further to four months in the mountains). A large amount of bending was needed in the mountains, averaging 65 to 70 bends per mile.

Accommodation was provided in trailer camps operated by the contractors in 1952, owing to scarcity of public accommodation in the sparsely-settled country. In 1953, as far as possible, the contractors had their men board out, even though this involved travelling as much as 30 miles to and from the job, as the cost of trailer camp feeding operations proved prohibitive and morale problems caused a great deal of trouble. As one spread superintendent said: "If a hand is feeding himself, he'll eat anything, but if you're feeding him he's very fussy."

Crossings Laid in Winter

An innovation in river crossings was carried out successfully on the Trans Mountain job, with the laying of most of the difficult crossings through the

● *Five miles west of Cushing, Okla., 10¾" Republic Electric Weld Line Pipe being laid.*

3 KINDS OF LINE PIPE ALL FROM REPUBLIC

● *This 24" O.D. Electric Fusion Weld Line Pipe is going in as part of a high pressure natural gas pipe line near Leeds, Alabama.*

Need Big Sizes? Republic makes Expanded Electric Fusion Weld Line Pipe in sizes 24" to 30" O.D. And it goes in *fast*. Circumference is always constant. Field joints line up accurately and quickly. The entire circumference can be welded at top speed. And to further speed field welding, uniform wall thickness provides an even distribution of metal all around the pipe.

From 2⅜" to 16" O.D. you can use Republic Electric Resistance Weld Line Pipe. Its high ductility assures smooth, uniform bends in the field or in the shop . . . without severe wrinkling. Uniform high yield strength permits building high pressure lines. Uniform wall thickness means dependability in every inch of the line.

Continuous Butt Weld Pipe made by Republic has been a standard in the oil fields for many years. It comes in nominal sizes ⅛" to 4" GRL, is used for gathering lines and many other oil and gas handling needs. It has uniform strength and ductility, tight adherence of the galvanized coating, is easily threaded, readily welded and bent.

When you need line pipe for oil and gas transmission, high or low pressure, remember, you can get all three kinds from Republic. Write for literature.

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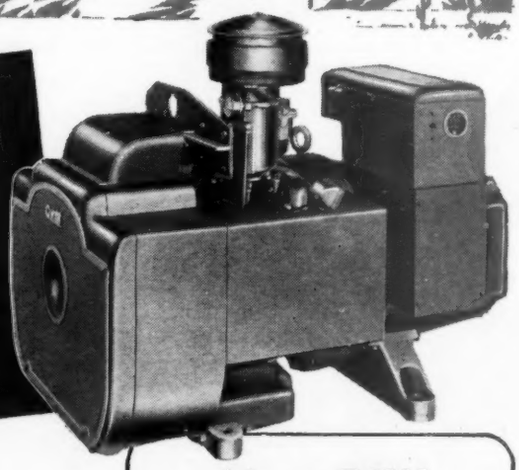

Microwave transmission is only as dependable as each of its relay links. If one repeater station cannot operate, messages do not get through.

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3,500 watts A.C.
2-cyl. air-cooled

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ice last winter, when the flow and the water level are both at their lowest. Rocky Mountain streams ordinarily flow at rates of 12 to 15 miles per hour and can carry excavated material back into place as fast as a bulldozer can dig it out. The success of the winter work was such, and the reduction of expense enough, that it will probably be repeated in the case of any other line laid through this region.

Future Trends

The most noticeable trend for the future in Canadian pipelining appears to be the increasing participation of Canadians in the industry. Two of the largest American contractors have incorporated Canadian subsidiaries that are practically all-Canadian in their staffing and operations. Several smaller contractors that had been engaged for many years in general construction work have been able to invade the pipe line construction business through small main line jobs and numerous gathering lines.

The ground work has been laid for the growth of an indigenous Canadian pipelining industry through the progressive training of construction personnel, just as it has been accomplished in the operating phase. This has been a very important public relations aspect of the acceptance of the industry and has built up a prospect of good relations in the future with right-of-way lessors, suppliers, government officials, and the local residents with whom the construction crews board along the route of the line. * * *

☆ ☆ ☆

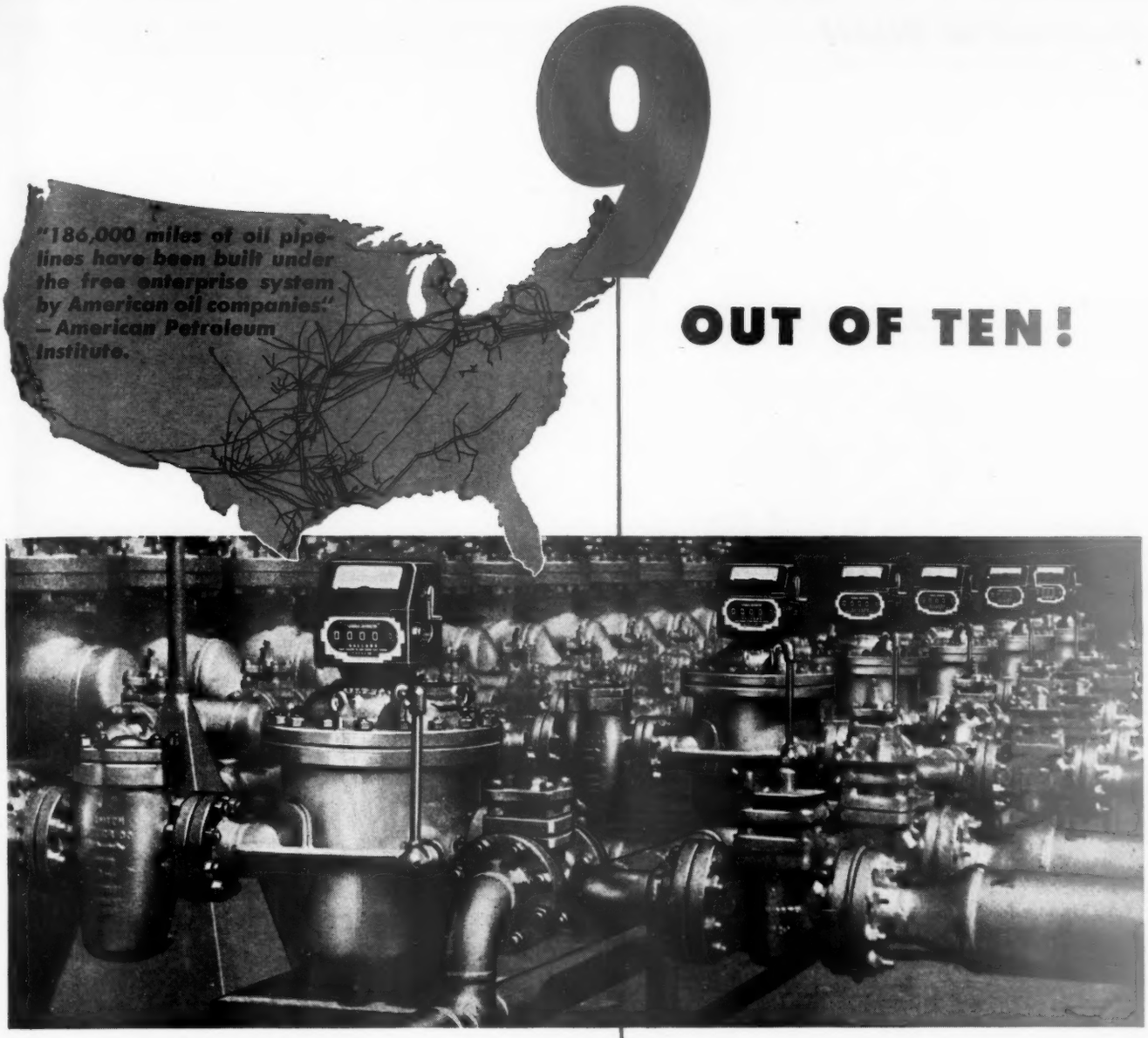
Two Companies Will Build Cross-Canada Gas Line

The cross-Canada gas pipe line from Alberta to the eastern area will be built jointly by two companies that have been competing for the right, according to announced plans of the Canadian government.

Trade Minister Howe has stated that the two companies will have to merge their corporate structures to fit in with plans of the federal and Alberta governments. The companies are Trans-Canada Pipe Lines, Ltd., which wants to build an all-Canadian line from Alberta as far east as Montreal, and Western Pipe Lines, Ltd., which would lay a line from Alberta east to Winnipeg then south to Minnesota.

Some time ago the Alberta government ruled that the two proposals should be amalgamated and the federal cabinet agreed. Trade Minister Howe's task is to bring about this unity of action.

As to the route of the line, it has been made clear officially that a line from Alberta to eastern Canada has precedence; that such a line must be assured, although not necessarily built, before gas is exported to U.S.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"186,000 miles of oil pipelines have been built under the free enterprise system by American oil companies." — American Petroleum Institute.

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Construction Report

BACKHOE, below, scratching away at tough malpais rock in Arizona. Ditch is shot before excavation on trench is begun.

DESOLATE, above, Arizona countryside surrounds pipeliners laying 30-in. line on El Paso project between Ashfork and Williams, Arizona.

"Backhoe Alley" Is Rough Digging Country

A 164-mile section of El Paso Natural Gas Company's new 30-in. line between Kingman and Flagstaff, Arizona, is becoming known as "backhoe alley", with eight backhoes forming the backbone of excavating operations for the new gas line construction. Rocky soil, too tough for trenchers, is drilled, blasted, and then handled by the capable backhoes.

Scene of the big backhoe operation is part of El Paso's new 30-in. line from the Permian Basin to Toprock, Arizona, that parallels U. S. Highway 66 between Flagstaff and Kingman.

Western Pipeline Constructors, Inc., of Austin, Texas, is contractor for the 164-mile section. Construction started in August on the 73-mile section between Ashfork and a point 25 miles east of Flagstaff. Elevation in this area is approximately 7000 ft. The spread will move to Kingman after completing the Flagstaff-Kingman section, and work eastward to Ashfork, a distance of 93 miles and complete the entire project some time during March, 1954.

Much of the soil encountered in the Ashfork-Flagstaff section is tough malpais rock, which requires blasting. Fourteen heavy duty portable air compressors, each supplying power for two drills, follow two trenching machines. The eight backhoes handle the shot rock and sections that do not require blasting, but are too tough for the trenching machines.

The pipe is gauge .329, and is tested to 900 psi and weighs 90 lb per linear ft. The pipe is being laid in this rugged northern Arizona section in a 60-ft right of way paralleling a smaller gas line that originates in the Farmington, New Mexico, field and which was constructed during 1951.

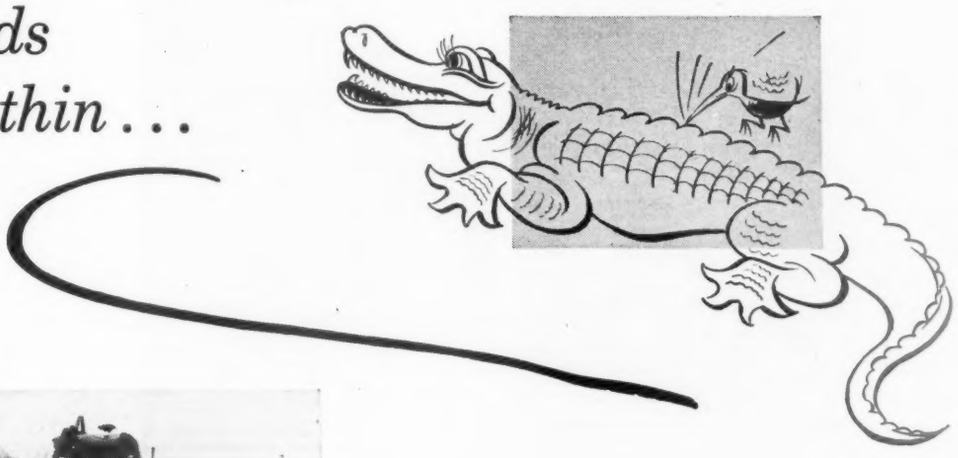
The trenchers excavate a trench 44-in. wide by 60-in. deep in caliche overburden. The two used on the job excavate an average 6000 ft of trench per 10-hour shift.

The backhoes used on the spread also average 6000 ft of trench of the same dimensions per 12-hour shift, operating in overburden consisting of caliche and broken malpais rock. A ¾-yd clamshell is used to complete the clean-up operation.

Where the tough rock is encountered, 2-in. blast holes are drilled 7½-ft deep. The holes are drilled at a rate of 12 holes per drill hour, or a total of 48 holes per hour for the double set of four drills. There are 14 compressors in use on this job. A caterpillar tractor is used to support four pneumatic drills and tow two air compressors used in blasting the pipe line trench.

Dunn Brothers, of Dallas, Texas, are stringing the pipe, which is in lengths up to 40 ft. A caterpillar tractor equipped with a pipelayer unloads pipe from trucks and places it into the pipe line stringing operation at the rate of slightly more than 1 mile per 10-hour day. Pipe is welded at a similar rate per day, and is held in place for the welding operation by tractors equipped with pipelayers. A six inch layer of padding is backfielded on the 30-in. line by using a tractor equipped with a bulldozer. * * *

Like the 'Gator's tough skin that shields what's within . . .



Johns-Manville Asbestos Felts shield oil and gas pipelines

Johns-Manville Asbestos Pipeline Felt—*the only type of wrapper that has survived more than 50 years of service in all types of soil*—now protects more than 100,000 miles of oil and gas pipelines!

A sturdy, inorganic product, Johns-Manville Asbestos Felt resists rot and decay, stands up in both acid and alkali soils. It has the thickness and toughness needed to shield pipeline enamels from earth load and soil stresses. And it permits the protective enamel coating to properly function against corrosion.

Johns-Manville Asbestos Felt is flexible; wraps easily without cracking. It guards enamel from impact damage both during installation of field-wrapped pipe, and during transportation and installation of mill-wrapped pipe.

There are important economic advantages, too! In addition to reducing maintenance expense, Johns-Manville Asbestos Felt adds many years of life to the pipeline. For further information and a sample of Johns-Manville Asbestos Pipeline Felt, mail the coupon below.

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Crossing barge canal in New York state at head of Lake Onendaga.

CONSUMER demands for petroleum products in the thickly populated and highly industrialized areas of Pennsylvania and New York, coupled with problems of inadequate transportation provided by other facilities resulted in construction of Buckeye Pipe Line Company's new 368-mile products pipe line system recently opened.

The new line answered the problems of shippers and consumers alike. Efficient and economical, it can be operated year-around, without a heavy capital outlay, compared to other transportation that is of seasonal nature and needs a heavy investment in terminal storage.

Products shipped via the new line originate at refineries in the Linden, New Jersey, area and from deep water tanker terminals nearby. Additional deliveries will be available with com-

*Eastern Editor.

EXCLUSIVE

P 615.05

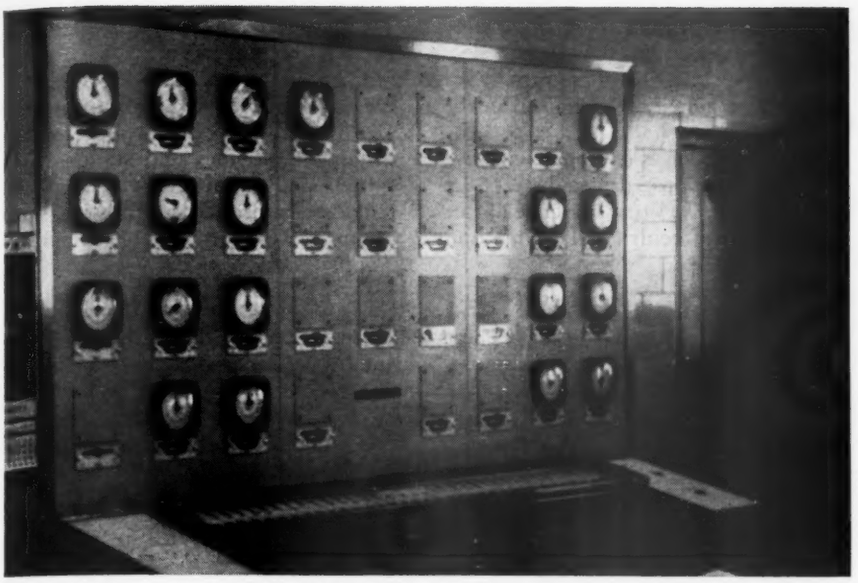
Buckeye Eastern Products Line Completed

New 368-mile, $24,000,000 line to ease products transportation shortage for East Coast markets

EUGENE B. BRIEN*

MAP OF Buckeye Pipe Line Company's new 368-mile Eastern products system.

VERTICAL TURBINE booster pump used on tanks to move products through manifold.



Tank farm control panel. Gate valve contols at bottom, telemeter gages above.

pletion of the Harbor Pipe Line bringing products from Philadelphia area.

After a careful and intensive market analysis and economic study, the design and route of the new line was decided upon. Planning for the 368-mile route, with an initial capacity of 100,000 bbl per day, began with a study of topographic and aerial survey maps. Terrain, location of existing shipper terminals, and construction problems dictated the route planning.

The route traverses some 1742 different plots of land, and crosses 504 roads, 58 railroads, 11 rivers, and 9 canals.

Between Linden, the originating terminal, and Macungie, Pennsylvania, there are 75 miles of 16-in. line, with a daily capacity of 106,000 bbl that can be increased finally to 188,000 bbl.

Going north out of Macungie, the line changes to 14-in. and terminates at Auburn, New York, 189 miles away. An 8-in., 8-mile spur runs from this line near Guthsville, Pennsylvania, to Allentown. Capacity of the 14-in. line is 92,400 bbl daily between Macungie and Nicholson station, and 80,300 bbl per day between Nicholson and Auburn. Ultimate capacity of the entire 14-in. line is 102,700 bbl daily.

Two 10-in lines extend from the Auburn station, one to Syracuse, 27 miles away, and the other to Caledonia, 69 miles in length. Capacity of the short line is 86,400 bbl daily, and the Caledonia lateral will handle 72,000 bbl per day eventually, but now limited to 48,000 bbl daily.

Construction of the line took two years, with the 16-in. line completed in 1952 and the remaining lines in 1953. Delays were caused by government material allocations spread over a two-year period, weather, late arrival of critical material, and other causes. The line was completed, however, within one month of the scheduled date.

Pump Stations

Five stations located strategically on the line provide the power to move the products at about four miles per hour,

H & M PIPE CUTTING AND BEVELING MACHINES NOW 40% LIGHTER!

HERE IS THE AMAZING STORY...

A completely new manufacturing process has made it possible to drastically reduce the weight of the renowned H & M Pipe Cutting and Beveling Machine. The search for a light, tough metal was started many months ago in an attempt to make the H & M line the lightest in its class without destroying any of its famous accuracy, long life, or economy. After months of searching, a satisfactory process was finally encountered. The H & M test model was rigged to an electric motor and the torch arm automatically sent around the pipe over 25,000 times. During the test, sand and other abrasive materials were blown into the highly machined gears, and the machine exposed to a multitude of simulated weather conditions. A micrometer check following this torturous test showed NO WEAR ON THE GEARS.

Here are the amazing new weights of the H & M Pipe Cutting and Beveling Machine: #3 machine — 14" to 20" pipe formerly 89½ lbs now 53 lbs.; #4 machine — 22" to 26" pipe formerly 123 lbs. now 66 lbs.; #5 machine — 28" to 36" pipe formerly 155 lbs. now 95 lbs. (all weights are approximate).

THE H & M . . . Lightest in its Class!

H&M PIPE BEVELING MACHINE CO.

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at the 100,000 bbl per day rate.

Biggest of the five is Linden station, which has three centrifugal pump units driven by 800-hp electric motors. Future expansion will add two additional units. Supplementing the main units at Linden are two 200-hp vertical turbine booster pumps, used to provide constant suction pressure.

At Macungie station, three centrifugal pump units powered by 800-hp electric motors are also in use, with provision made for one future additional unit. Two 150-hp vertical boosters are used to maintain suction pressure.

Lehighton station has three and Nicholson station has two 700-hp electric driven centrifugal pumps. One unit will be added at Nicholson in the future.

Auburn station is equipped with five piston-type pumps, driven by 215-hp diesel engines. Future plans call for an all-electric, centrifugal pump unit plant.

Tank Storage

Along the system, 31 working tanks are located at the five stations, with floating roof tanks used for gasoline and gas-type tanks for other products. Two sizes of tanks are provided, 54,000 and 80,000 bbl.

Each of the tanks has a vertical turbine suction pump ranging from 25 to 50 hp, used to boost the product through tank lines and station manifolding to the main station pumps. All tankage is also equipped with sump pumps so that it may be completely emptied.

Operations

Operation of the system is semi-automatic and controlled from a central control desk, where remote readings are made of pressures, temperatures, flow rates, and tanks are gaged by telemetering. Safety precautions have been built into the equipment, including sound alarms on abnormal operating conditions and automatic shutdown in case of emergency. Loss of pressure or overpressure, motor or pump failure, extreme temperatures will start the shut-down process.

Switch gear stations are provided with automatic CO_2 devices and fixed foam nozzles are provided at each tank as precautions against fire.

Fourteen companies will use the system, which is operating as a common carrier, and they will tender some 25 individual products, mainly gasoline, kerosine, diesel fuel, and heating oil. Each product is batched separately. Strainers and separators at each station and terminal remove sediment and keep products clean. An oil soluble inhibitor is injected into all gasoline tenders as protection against internal corrosion.

Dispatching operations are centralized at Macungie, from where all stations and terminals are kept in constant communication via teletype communications. All batches are continuously traced on a master dispatching board. * * *

Diesel-Powered Tows Grow In Size and Importance

Longest luxury liner on the high seas is dwarfed by the great, integrated tows, many of them carrying petroleum, which operate on America's 28,383 miles of inland waterways. Diesel-powered tows, some of them measuring 1170 ft long at the water line (in comparison with the Queen Elizabeth's 987.4 ft), are operating on the Mississippi and Ohio Rivers and the Illinois Waterway. Some tows of eight tank barges have a cargo capacity of nine million gallons of oil. The railroad tank car has a capacity of 8500 gal, and the average tank truck's capacity is 5200 gal. Oil men use all of these transportation methods, plus pipe lines and ocean tankers, to speed oil and its products to American consumers.

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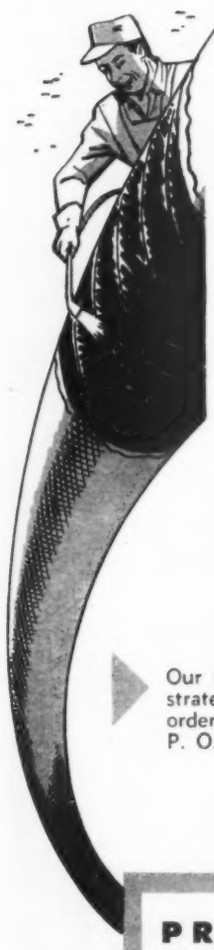

PROTECTO WRAP is a hot applied protective coating in roll form for field joints on mill or yardcoated pipe, fittings, couplings and other metal surfaces exposed to above and below ground corrosion.

PROTECTO WRAP consists of a plasticized coal tar or asphalt enamel, of the types used for pipeline coating, saturated into a glass fabric that acts as a carrier and reinforcement for the enamel. PROTECTO WRAP is interwoven with a paper separator that insures even distribution of the coating as well as easy unwinding, regardless of temperature. The material is used to coat mteal surfaces where the quality of hot applied reinforced bituminous coating is desired.

PROTECTO WRAP is available in 2, 4 and 6 inch widths, fifty feet in length; and in 18 and 24 inch widths, 30 feet in length.

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The Baldwin SR-4 Load Sensitive Unit Type T—20,000 Pounds. This newly designed cell, of monel metal construction, stands the rough treatment and corrosive atmospheres of the oil fields.

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THE BALDWIN SOLUTION:

Specially designed Baldwin SR-4 Tension Links, hung between the top sheave and the derrick cap, measure the tension in the cable supporting the survey equipment being used in the hole. Baldwin SR-4 devices operate on the principle of the famous SR-4 bonded wire strain gage.

SCHLUMBERGER BENEFITS:

1. When lowering equipment, suddenly decreased tension indicates a hang-up of equipment in the hole. Saves time—insures accurate records.
2. While in the hole, a continuous rough indication of cable and tool weight gives the operator an additional protective check for smoothness of his survey operation.
3. When pulling equipment up, suddenly increased tension indicates equipment caught in the hole, allowing correction to avoid cable breakage and losing or damaging expensive instruments. Saves time—saves money.
4. In field use, corrosive conditions and rough treatment are easily withstood by this Baldwin SR-4 unit. Avoids costly down time.

Baldwin SR-4 devices have uses unlimited in industry—measuring load, fluid pressure, or torque economically, speedily, and accurately. For the latest technical information please write to Department 3330, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

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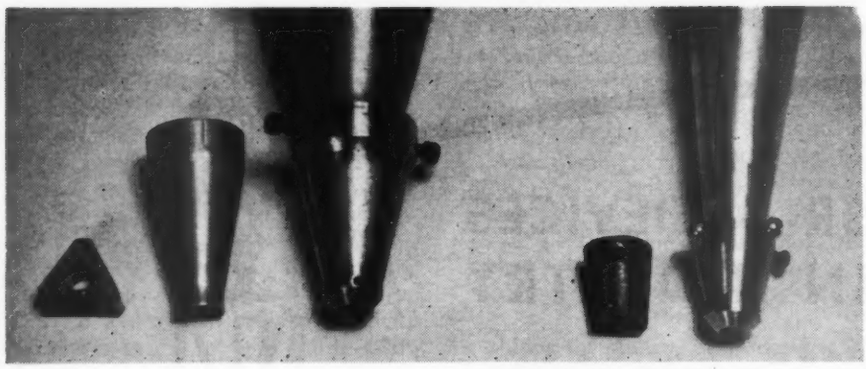
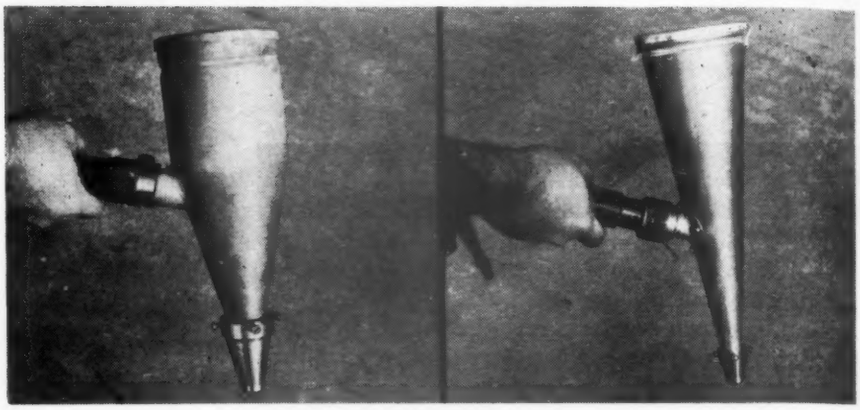


Close-up of two types of adapter tips installed on standard hoppers. Original tip shown with each.



Two types of hoppers in common use fitted with adapter tips.

ADAPTATION OF SEMI-AUTOMATIC WELDER TO MAGNETIC FLUX

R. A. HAND*

AN extremely simple, inexpensive nozzle adapter for the conventional semi-automatic or "squirt" welder gives promise of a new and considerably wider use for this machine. The device makes possible the deposit of various alloys at speeds far higher than can be obtained by ordinary manual welding, even exceeds the deposition rate achieved by the full automatic electric welding head. In essence the process utilizes the magnetic field created by the passage of the electric current through the bare electrode, plus a magnetic alloy flux that coats the wire immediately ahead of the welding arc. The operating cycle is completed by the use of permanent magnets in the nozzle adapter that act as a dam to the flow of flux whenever the arc is broken.

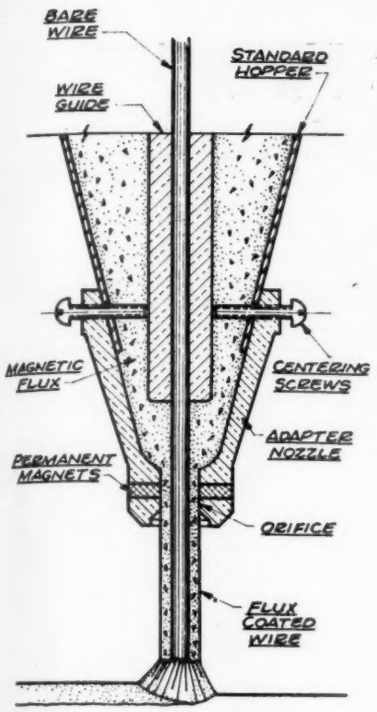
The whole process is merely a combination of two accepted and proved welding methods — the squirt welder, which uses a granular non-magnetic flux to produce the common submerged melt deposit, and the magnetic flux method of automatic welding as perfected by Brown Boveri in Switzerland some years ago. The squirt welder, employing the hidden arc beneath a simple flux, is in everyday use and is familiar of course to all those interested in welding.

The Brown Boveri method is less widely recognized. Basically it depends upon use of the magnetic field surrounding the welding electrode in conjunction with a granular magnetic metallic flux. In this machine the flux in the standard hopper is fed by gravity to a cup around the contact jaws. Thus, when the arc is established the magnetic lines of force cause the flux to adhere to the wire, producing what is to all intents and purposes a coated electrode. The amount of flux applied to the wire is governed by the size of the orifice in the cup. In the Brown Boveri equipment an electrode-magnetic coil in the cup acts as a dam when welding is interrupted. This general process was covered by European patents some eight years ago and has been used since then for mild steel fabrication much as the submerged melt process has been employed.

Some time ago Stoody Company became interested in magnetic flux as a possible method of applying alloy materials through semi-automatic welders, the use of which is limited to small diameter wires, generally 5/64 in. and 3/32 in., sizes too small to be fabricated into tubular wires such as provided for application through the full automatic head.

As applied to build-up and hardfacing, the magnetic process provides high deposition rates (8 to 20 lb of deposited metal per hour, using 5/64 in. or 3/32 in. wires); deposition rate will depend upon amperage. Deposits are sound, with the consistency and uniformity characteristic of the automatic

*Automatic welding specialist, Stoody Company, Whittier, California.



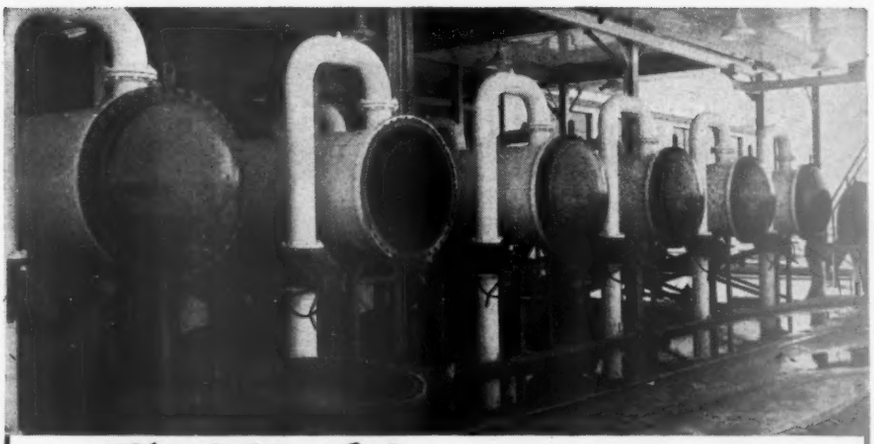
Cross section through adapter nozzle.

welding method. Time lost in changing electrodes is eliminated and there is of course no stub-end loss.

By comparison with the semi-automatic hard-facing method utilizing an alloy submerged melt flux, the magnetic process eliminates considerable waste, since all the flux applied to the wire is consumed. This feature also makes unnecessary flux recovery equipment and screening for re-use. An important consideration is the fact that with the magnetic process the welder is using an open arc, which allows him to see the actual welding at all times, gives him better control of the deposit, and permits the hard-facing of irregularly shaped parts. Although the conventional hopper is of small size for ease of handling, it is necessary to refill it only infrequently, since the ratio of deposited metal to flux used is approximately equal. Another feature is that no flux dams, jigs, or fixtures are needed.

Squirt welders now in common use may all be readily adapted to operate with magnetic alloy flux. The photographs and sketch show how the adaptation is made. The adapter tip containing the permanent magnets replaces the standard tip, centers the wire to assure a concentric flux coating and governs the amount of flux applied to the wire.

A series of magnetic flux materials designed for both build-up and the application of hard-facing overlays has been developed and will soon be available. * * *



EXCEL-SO *Combination*

SEPARATOR – FILTER – AIR ELIMINATOR

. . . for removal of bulk quantities of water, pipe scale, and rouge from products Pipelines . . . . .

These HPQ-1000 SC Separators are in use at Plantation Pipe Line Company's Baton Rouge Pumping Station. Today, more and more Products Pipe Line Companies are using EXCEL-SO Units to remove water and dirt from products streams either as primary coalescers or as first-stage units in connection with desiccant dehydration.

Write for Bulletin FEQ-51

WARNER LEWIS COMPANY

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AIR • GAS • AMMONIA / compressor operators

DID YOU KNOW...

you can build peak performance into your oldest compressors!

and obviously into your newer, high speed machines, too!

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if you want peak performance **. . . increased efficiency . . . greater output . . . lower power costs with utmost safety, investigate the advantages of VOSS VALVES for your machines.**

VOSS VALVES provide. . . **Quiet, vibration-free operation • 20 to 60% more valve area • less power consumption • low pressure loss • normal discharge temperature • lower operating costs • utmost safety.**

To increase the efficiency of your compressor, send us the name, bore, stroke and speed of your machine. Our detailed proposal will be sent without obligation.

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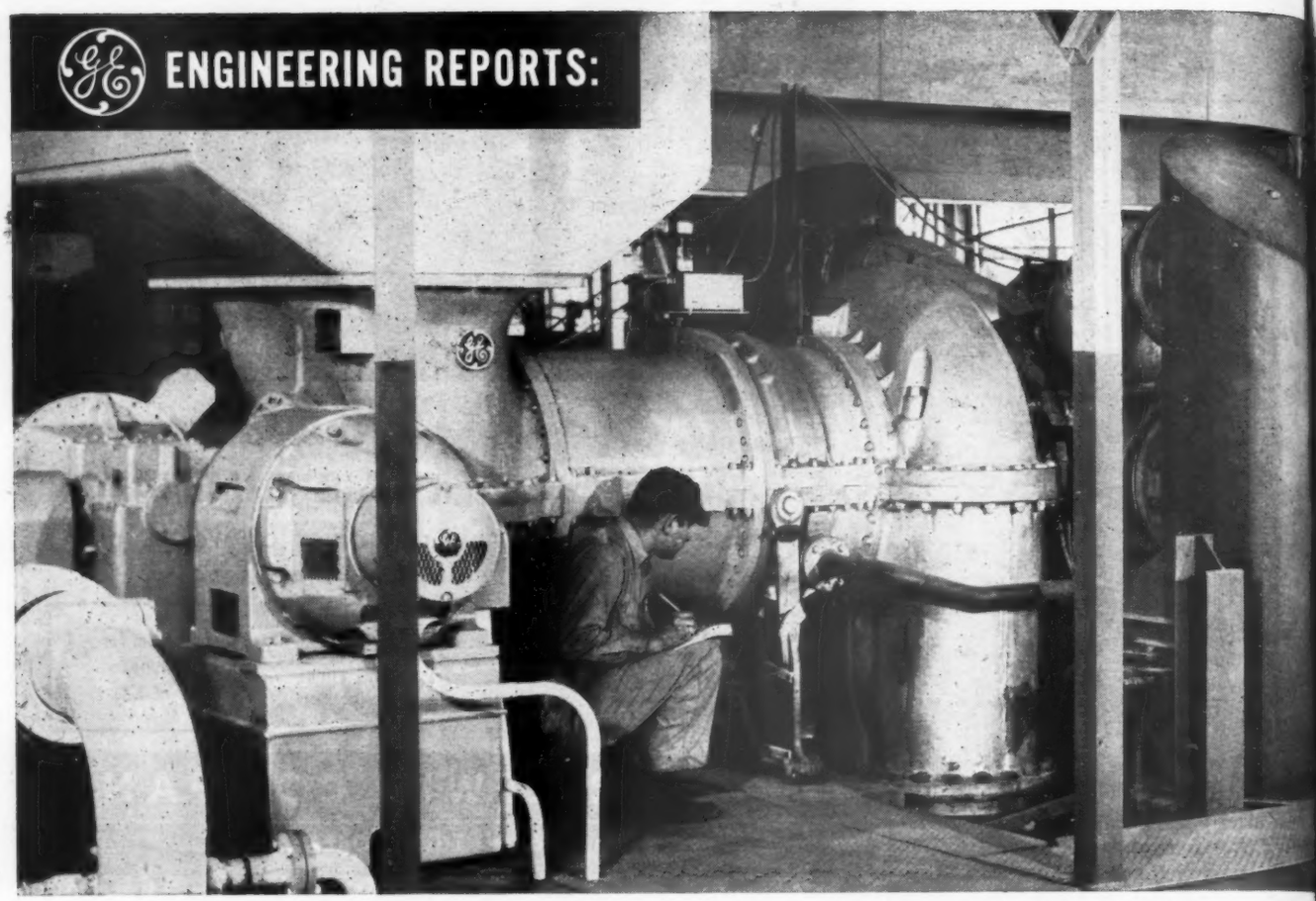
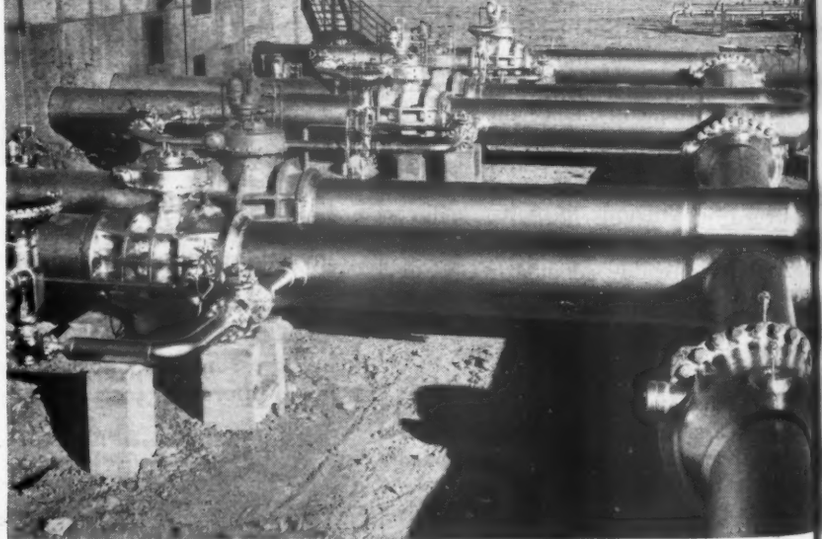
ENGINEERING REPORTS:



This G-E gas turbine is the first of 28 installed for gas pipeline pumping by the El Paso Natural Gas Co.

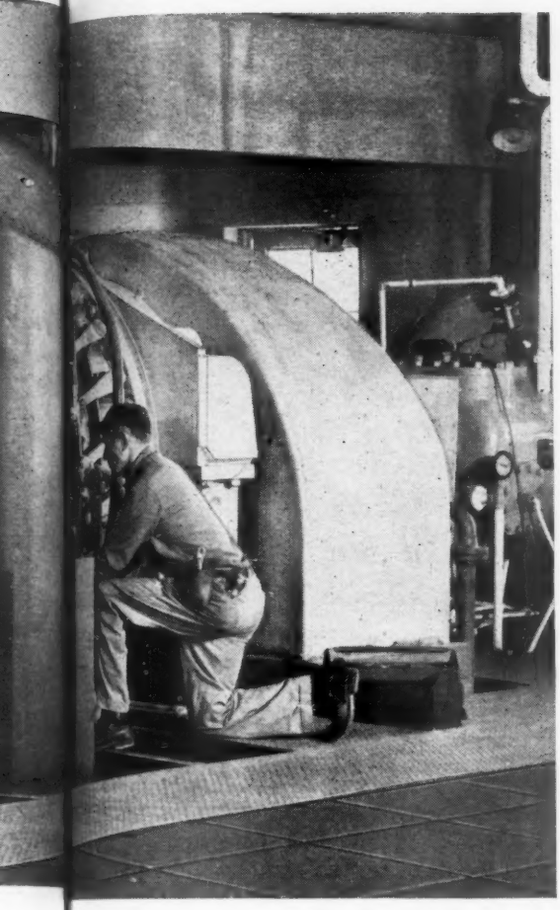
El Paso reports performance of G-E

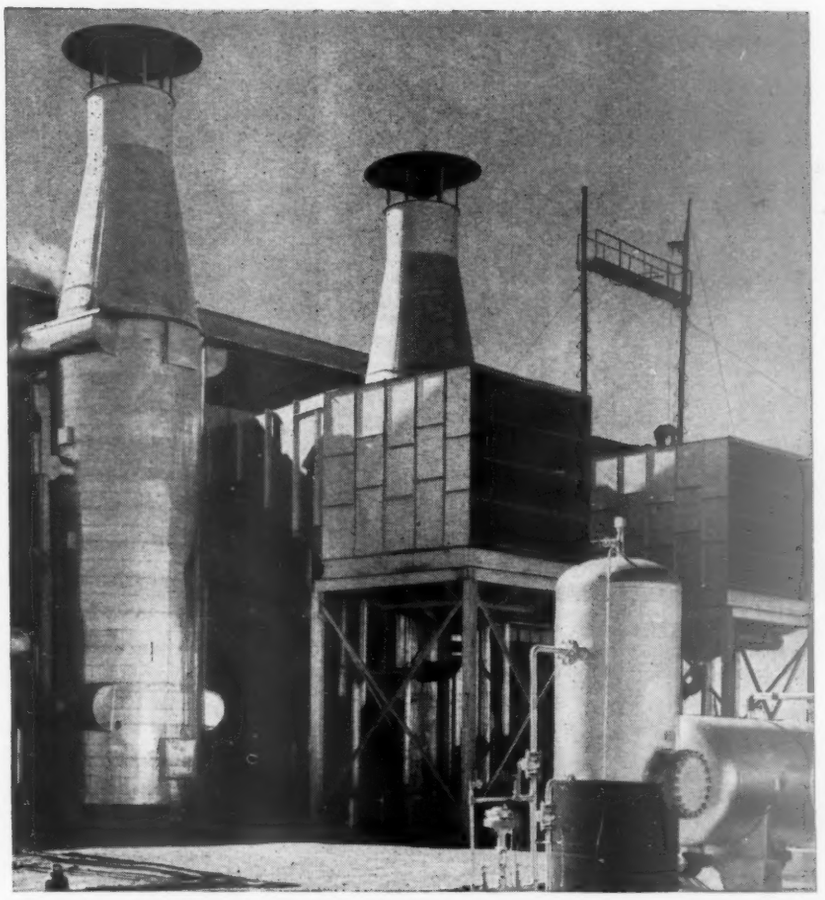
NO OUTSIDE POWER IS NEEDED—panel above provides control for station auxiliaries. Auxiliary generator, driven by the turbine, provides all a-c power while turbine is operating.



MAIN GAS PIPING is simplified by use of gas turbine-driven centrifugal compressors. The suction and discharge valves, purging and pressurizing valves are all controlled automatically on start. The G-E gas turbine is automatically loaded, and the station discharge pressure is maintained automatically.

XUM





HIGHER EFFICIENCY—regenerators "recapture" waste heat, enable turbines to pump with efficiencies comparable to other types of power plants.

gas turbines exceeds expectations

Records of first 15 combustion gas turbines used for pipeline pumping show they start fast, save fuel, simplify operation

So far, El Paso Natural Gas Company has put 15 General Electric combustion gas turbines into operation on their cross-country gas line. Performance has been carefully watched. El Paso has found:

1. **Stations start in 19 minutes—automatically.** Station batteries and pipeline pressures do it all.
2. **Five-man crews can operate stations.** The simple construction of the turbines means reliable performance, easy operation, less maintenance.
3. **Operation proves turbine flexibility.** During nine months of operation under fluctuating conditions, the turbine at Cornudas Station performed with even greater flexibility than had been predicted.
4. **Personnel training system is highly satisfactory.** Key El Paso personnel were sent to the G-E gas turbine plant for intensified training. They in turn trained regular operating staffs. All new positions have been filled by company personnel.

G-E system engineers will be working closely with El Paso engineers during installation of the 13 combustion gas turbines still to go on the line. Your G-E Apparatus Sales Representative can tell you more about their services—and about the G-E gas turbine. Ask him also, to arrange for a showing of the new full-color film, "The El Paso Story," or write to General Electric Company, Schenectady 5, New York. 661-41

Combustion Gas Turbines for the Gas Pipeline Industry—Backed by 45 years of Turbine Leadership

GENERAL ELECTRIC

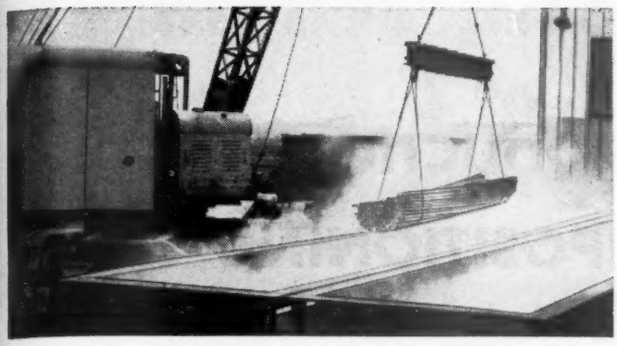
JACK BEAMAN (closest to camera in left photo), H. C. Price Company foreman, supervises boring of a road crossing on the Gulf Interstate Gas Company main line not far from Columbia, Kentucky. Six sideboom tractors, right photo, prepared to lower in a section of 30-in. pipe at a crossing on Green River in eastern Kentucky. Huge river clamps weigh 3750 lb per set.

Pipe Line Pictorial

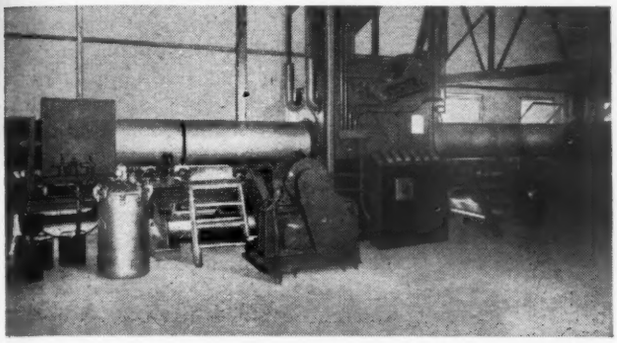
Gulf Interstate Line Construction

JOHN HAMILTON, Price cleanup foreman, stands near top of embankment at Big Black River a few miles from Kosciusko, Mississippi. Nearly 9000 sacks were used to protect four 12-in. Southern Natural Gas Company lines against washout.

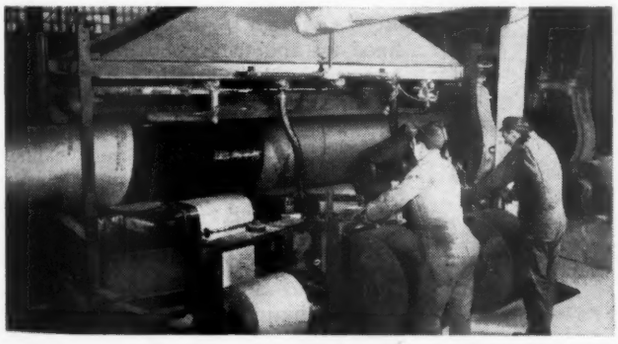
PAIR OF giant ditching machines carve out a trench for 30-in. Gulf Interstate Gas Company pipe line being laid in Kentucky and Tennessee. Coated with somastic and hevicote, this section of 20-in. pipe is ready for a shove through swamps of southern Louisiana where United Gas Pipe Line Company is laying a line from Lirette to Harvey.



HOT CAUSTIC DIP removes all cutting oil and grease. Pipe is then rinsed in clear, hot water and dried in warming room. Throughout Hill, Hubbell process, pipe is kept at 80-90° to prevent moisture condensation.

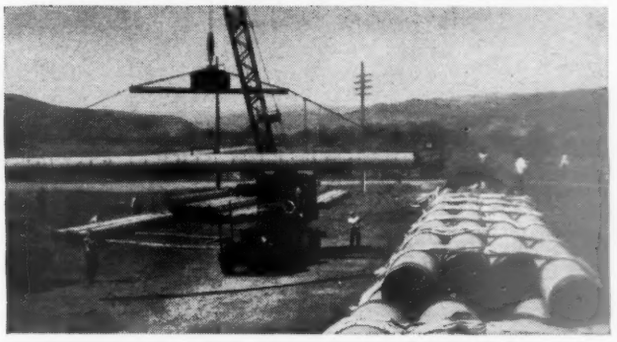


ROTO GRIT BLAST removes all mill scale and rust, cleans pipe to bare, bright metal, provides a slight "tooth" to hold coatings in positive bond. Priming coat is applied immediately after Roto Grit Blast.



SECRET of Hill, Hubbell superiority is applying enamel in multiple 1/32" coats instead of one thick coat—pipe protection insurance that pays off in the field. Then pipe is tightly wrapped under even tension by special machines.

Why HILL, HUBBELL Factory-Coated Pipe Lasts Longer



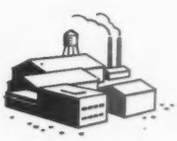
ELECTRONIC holiday detectors inspect every length of pipe before it leaves a Hill, Hubbell plant—further insurance that coatings have dielectric strength to resist electrochemical corrosion underground.

THREE HILL, HUBBELL PLANTS TO SERVE YOU:

GIRARD, OHIO
in the Youngstown Switching Zone

LORAIN, OHIO

HAMMOND, IND.
Chicago Switching Zone (in transit privileges)



Hill, Hubbell and Company
Division of GENERAL PAINT CORPORATION

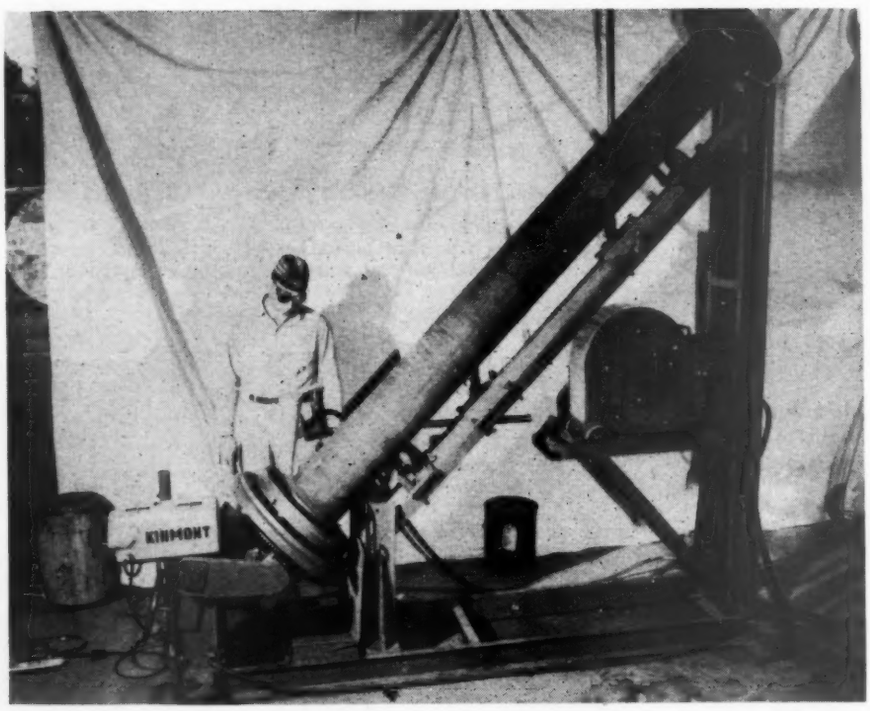
Headquarters: 3091 Mayfield Road, Cleveland 18, Ohio

Pioneer in Pipe Protection for a Quarter Century

XUM

Pipe Line Procedures

METER RUN PRODUCTION INCREASED BY NEW POSITIONING JIG



THIS NEW TURNING and positioning rig, developed in Northern Natural's South Omaha meter shop is used for welding flanges on pipe primarily for meter runs. Using rig, a 10-in. flange can be welded on a pipe in two minutes, an operation that took 75 minutes before it was developed.

METER run production capacity of Northern Natural Gas Company's South Omaha (Nebraska) meter shop has been doubled with the development of a turning and positioning jig by members of the shop staff under direction of Anton Steinbacher, shop superintendent. Using the jig, a welder and helper can now turn out four complete 4-in. meter runs per day, compared to a two-per-day performance prior to development of the new device.

The jig consists of an automatic concealed arc welding machine, a hopper with a hose connection that feeds the flux around the weld, and the positioner for rotating the pipe automatically. The jig is capable of welding flanges on the inside and also on the outside of pipe from four to ten inches in diameter. Although the flange must still be lined up and tacked by hand-welding before it is placed on the jig, the actual welding can be done in two minutes, an operation which formerly took approximately 75 min by hand welding.

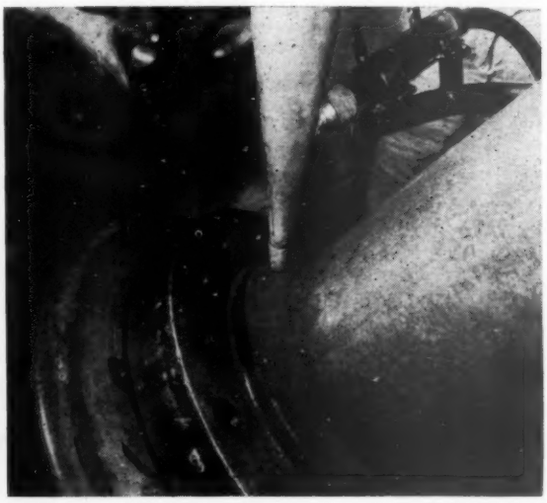
Steinbacher got the idea for the jig when he visited a steel fabricating plant and saw a jig for welding flat surfaced metal in a horizontal position. Because meter runs must be welded on the round, a jig incorporating many of the same principles, but completely different in design was developed.

Such items as the proper heat, amperage, and voltage were necessarily taken into consideration. The positioner was designed so that the pipe would be rotated at the correct speed in inches of weld per minute for proper penetration into the metal, and the problem of lapping over as each cycle was completed had to be solved. Another problem was keeping the hot metal from running off the pipe during the welding process. This was solved by constructing the jig in such a manner that the pipe tilts at a 45 deg angle.

The jig is still in the development stage and improvements are constantly being made. Through the use of the jig, stronger, smoother welds are obtained and shopmen have high hopes of making even further progress in cutting down production time. * * *

CLOSE-UP of a finished weld.

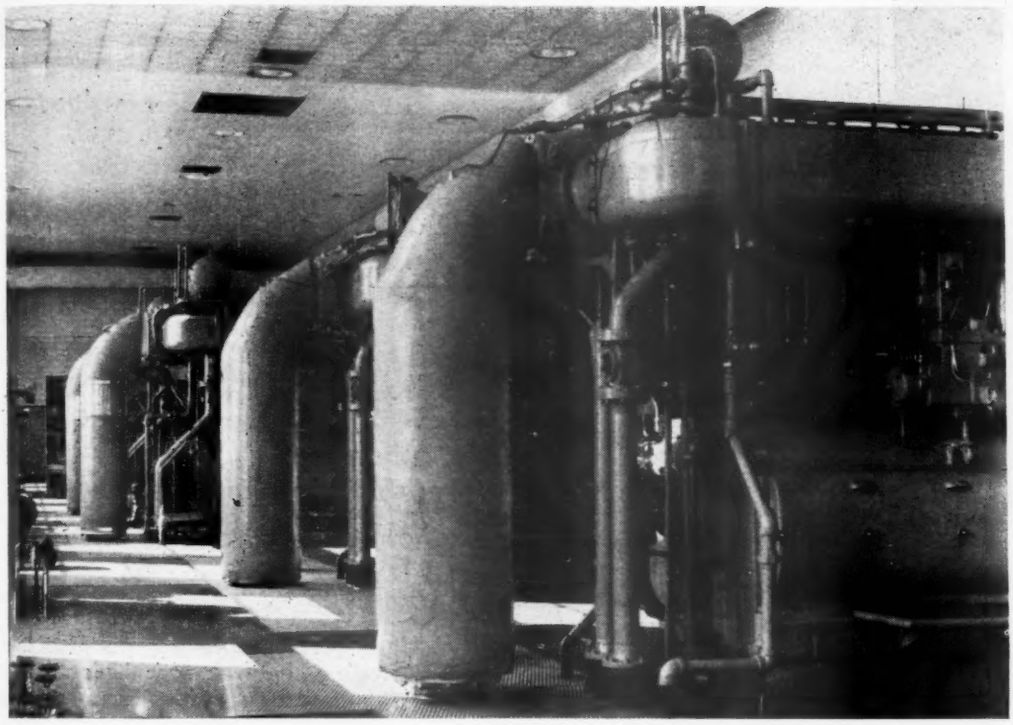
FLANGE WELDING on the jig in progress.



Another Pipe Line Company Reports

2 to 3 times more horsepower hours

. . . after installing Koppers Conformable Oil Rings



Koppers Porous Chrome* Rings. Porous chrome surface holds and distributes oil during break-in. Seats quickly. This chrome prevents grit from embedding in ring surface. Prevents cylinder wall scratching. Reduces wear 50%. Last 4 times longer than other rings.

Koppers Conformable Ring maintains constant unit pressure for positive oil control. Conforms readily to meet cylinder distortion because flexible cast iron member is pressed outward by abutment type spring which exerts uniform radial pressure around entire circumference.

*Van der Horst Process

Here's proof that Koppers Piston Rings increase operating efficiency.

Prior to using Koppers Conformable Oil Rings, a pipe line company reported average oil consumption as approximately 3500 to 4000 horsepower hours per gallon. Now they are getting 2 to 3 times that much.

In addition to this large saving in oil consumption, they find they get longer periods of satisfactory operation between overhauls.

As a result, this pipe line company has adopted Koppers Piston Rings as standard equipment on all their 12½" x 13" turbo-charged engines.

Does this suggest possible savings in your operation? Less oil consumption? Less down time, lower labor costs? Then investigate Koppers Porous Chrome* and Conformable Oil Rings. And install them next time you have a piston ring replacement job.

Write for special assistance from our experienced technical staff. No obligation, of course . . . . and mail the coupon for special conformable ring folder.

KOPPERS®

AMERICAN HAMMERED
Industrial Piston Rings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore, Maryland

This Koppers Division also supplies industry with Fast's Couplings, Aeromaster Fans, Koppers Electrostatic Precipitators and Gas Apparatus.

Engineered Products Sold with Service

KOPPERS COMPANY, INC., *Piston Ring Dept.*, 1592 Hamburg Street, Baltimore 3, Md.

Gentlemen: Please send me full information on your Conformable Oil Ring.

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Company ----------

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City ---------- Zone ---------- State ----------

TO REPAIR PIPE LEAKS – QUICKLY, PERMANENTLY

ANY PRESSURE — ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.

SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY

SOUTH BEND 21, INDIANA, U. S. A.

MOLE

Pipeline Cleaner

for BETTER cleaning of

CRUDE LINES

PRODUCT LINES

NATURAL GAS LINES

FOR DETAILS WRITE

Pipeline Cleaners Co.

Fort Madison, Iowa

SCRAPER TRAP at Somerset, Manitoba, showing how special couplings were used on loop tie-in of Interprovincial line. Bolts remain to be tightened in this picture.

P 615.222.

Pipe Line Procedures

Interprovincial Loop Tie-in Time Cut to 27 Hours

Careful planning, prefabrication of sections credited in fast, economic tie-in operation

EXCLUSIVE

COSTLY down time, calculated at $3000 per hour, was cut to 27 hours for tie-in of four sections of 24-in. loop on the Interprovincial Pipe Line Company's main line between Regina, Saskatchewan and Gretna, Manitoba, last September. Careful planning and close supervision are given the credit for the expeditious performance.

Anderson International Contractors, Ltd., of Edmonton, Alberta, contractor for the 135-mile loop construction, installed the tie-ins, with a minimum down time of 40 minutes and maximum of three hours. Most of the total time was occupied by line drainage, some of which was taken by station tanks but most by the loop sections, which were previously empty and were filled by portable pumps.

Preliminary work consisted of prefabricating tee sections, 16 by 16 by 24-in., using special manufactured couplings. The eight crossover tie-ins, all made at scraper traps, one at each end of each of the four loop sections, required sixteen couplings, two for each tee section. The tee sections were made about 2-in. shorter than the pieces to be cut out of the main line, which were about 5 ft long. This simplified make-up of the flanged branch joints.

The prefabricated sections were inserted into the cut-out main line pipe and were clamped into place so that welding could be done later without shutting down again. Thrust screws were used at the ends to compress a Neoprene packing ring and make an oil-tight seal. It is claimed that pressure up to 3000 psi can be handled with this seal, and in practice, the couplings withstood pressure of 1050 psi for several days before welding could be completed.

Square head thrust screws were used on the Interprovincial job and were later cut off flush with the coupling ends for seal welding. Fillet welds were made with three 3/16-in. passes to complete each joint, welding downhill the same as in normal butt-welding.

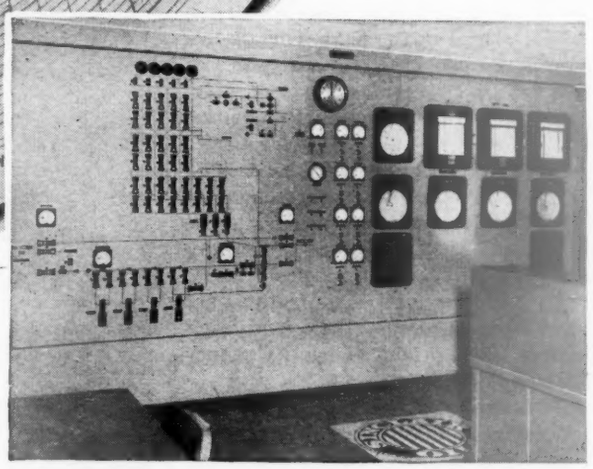
One special situation was met by use of the pilot bevel, a longer, more tapering bevel than normal bevel of pipe ends for welding. At one location the main line cut caused the ends to jump out of position because of a condition of strain. The couplings were then lowered into the ditch ahead of the tee section, were slipped back over the pipe ends and the tee section lowered into place. Wire ropes were fastened to projecting side screws and the coupling was drawn on end-wise at each end. The extreme taper of the pilot bevel permitted the Neoprene packing to be crowded back as the coupling was pulled over the tee section pipe end, so that the coupling would be guided into position more readily. * * *

Here's 1 Controller that holds 2 related variables within set limits

The NEW FOXBORO M-40 AUTO-SELECTOR

This Unique Controller operates from two related measurements automatically transferring control from one to another as required to prevent either one from exceeding its set limit. When supply is greater than demand, control is maintained on the demand side (discharge) . . . but when demand exceeds supply, control is maintained on the supply side (suction).

The M-40 Auto-Selector has two measuring elements and control mechanisms — also a combined air relay. It actually does the work of two instruments . . . with one or the other variable under control at all times. The transfer of control from one variable to the other is smooth, instantaneous, and with no upset. Any type of control action may be used. Any combination of related variables may be controlled-pressure and flow; temperature and level; two flows; two pressures; etc.



SINCLAIR PIPE LINE COMPANY'S new 670 mile, 22-24 inch line from Cushing, Okla., to East Chicago is operated by all-Foxboro control instrumentation, based on the unique Auto-Selector Controller. Above: part of control panel at Cushing Station.

Write for details. The Foxboro Company, 642 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO
REG. U. S. PAT. OFF.

RECORDING · CONTROLLING · INDICATING
INSTRUMENTS

Visual Identification of Line Pipe†

Various types of line pipe can be easily identified by field man through characteristics produced during manufacture

HANS SCHMOLDT*

OFTEN during the course of his work it would be interesting or relevant for the engineer in the field to be able to identify specific kinds of pipe as to their method of manufacture. Although it would require a complete laboratory examination to positively identify a specimen of pipe as to its specific API or ASTM specifications, this brief report points out the characteristics of the various kinds of line pipe so that they may be readily identified by visual examination when mill stenciling or other identification has been lost.

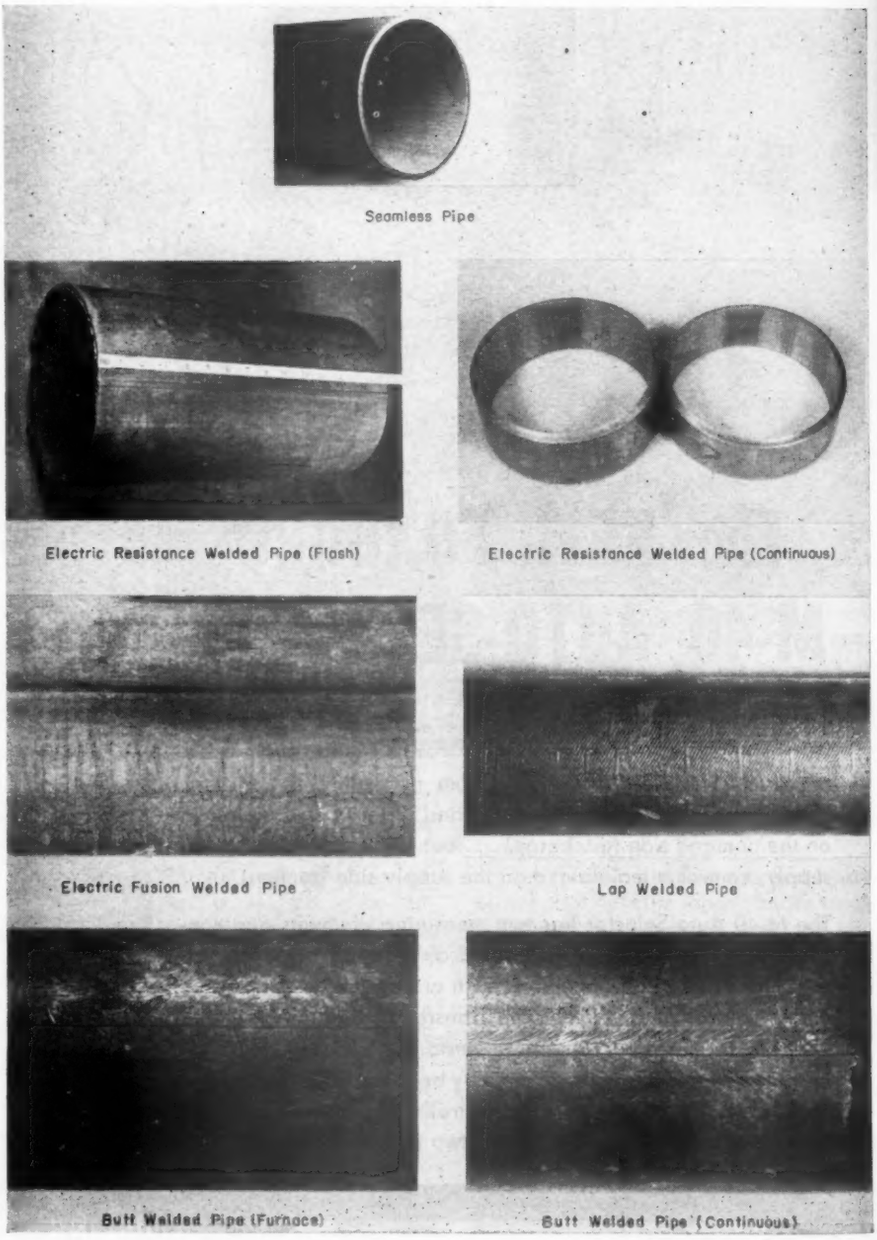
A more complete study or pipe identification should include an understanding of the various steps of mill fabrication and a knowledge of a few simple and basic metallurgical tests which can be performed in the field. This discussion is not concerned with qualities or deficiencies of various kinds of pipe, nor their proper selection for field or plant use.

Line pipe generally can be classified into five groups related to method of manufacture. Although mills attempt to produce the ultimate in uniformity and quality under a given specification, some processes of manufacture are more efficient than others and each kind of pipe produced has its proper field application.

The five common pipe fabricating processes produce pipe that can be classified as follows: Seamless, electric resistance welded, electric fusion welded, lap welded, and butt welded. In general, it can be said that although all imperfections are not injurious, pipe can be identified most easily through defects occurring during fabrication.

Seamless Pipe

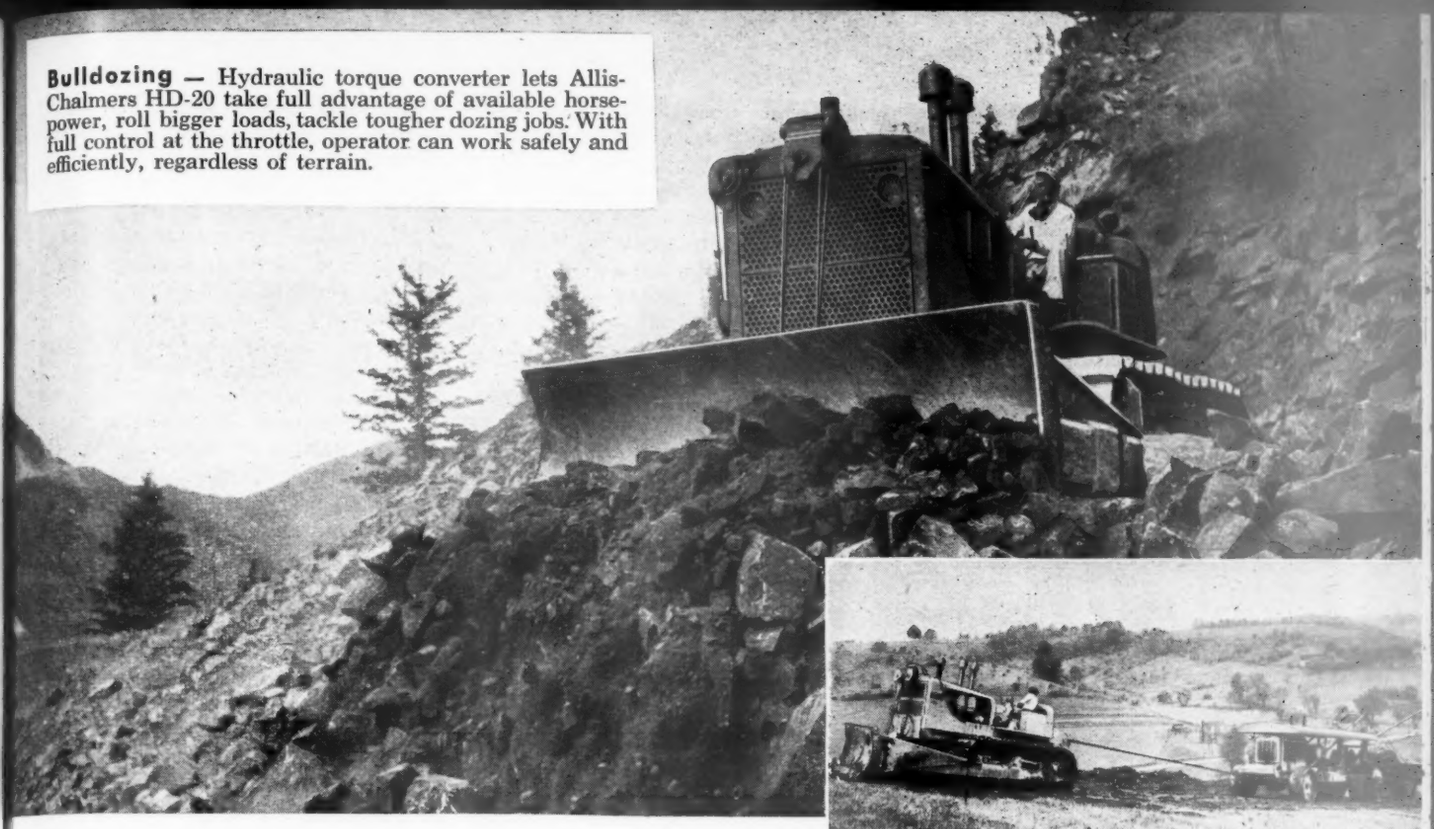
Seamless, as the class name implies, has no welded seam, but is produced by spinning and pushing a heated bil-



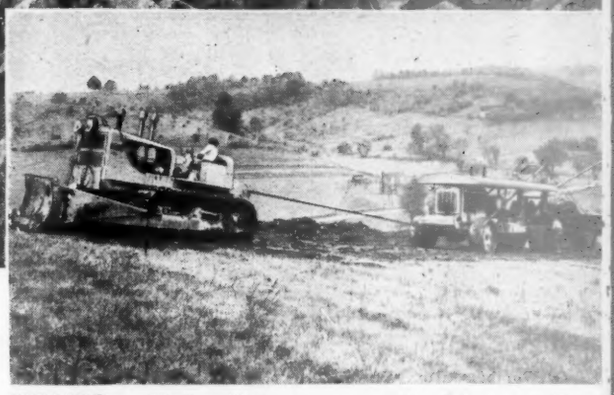
Characteristics of various types of pipe.

†Reprinted through courtesy of *Corrosion*, official NACE publication.

*Huddleston Engineering Company, Bartlesville, Oklahoma.



Bulldozing — Hydraulic torque converter lets Allis-Chalmers HD-20 take full advantage of available horsepower, roll bigger loads, tackle tougher dozing jobs. With full control at the throttle, operator can work safely and efficiently, regardless of terrain.



PULLING — Hydraulic torque converter drive actually multiplies torque up to four and one-half times . . . develops tremendous drawbar pull to start the load smoothly . . . and automatically accelerates to the highest speed that conditions permit, in either high or low range.

AN ALLIS-CHALMERS REPORT

How hydraulic torque converter drive improves big tractor performance — increases job output

With a two-range transmission and hydraulic torque converter, the Allis-Chalmers HD-20 is the only crawler tractor that is capable of exerting maximum drawbar pull *at all times* . . . under all load and terrain conditions . . . without gear-shift guesswork.

Whatever the job, the operator need merely make contact with the load and then open the throttle. As the load requirements change, the hydraulic torque converter *automatically* matches the conditions with exactly the right combination of speed and pull.

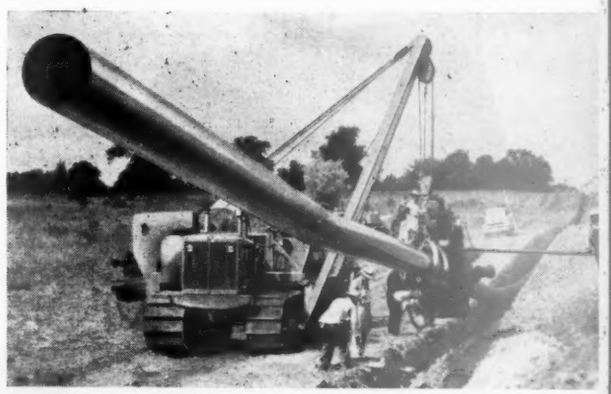
This eliminates most shifting . . . leads to far more work done in a continuous work cycle . . . far longer equipment life.

• • •

Hydraulic torque converter drive, exclusive as standard equipment with Allis-Chalmers, is just one of many reasons why the HD-20 assures you higher output with less upkeep. Your nearby Allis-Chalmers dealer invites you to get the full story . . . and to see it in action.

WEIGHT — 41,000 LB. • 175 NET HP. AT FLYWHEEL

ALLIS-CHALMERS
TRACTOR DIVISION — MILWAUKEE 1, U. S. A.



SIDE BOOM WORK — Torque converter drive makes it amazingly simple for operator to match cradling speed to cleaning-priming, doping-wrapping machines. And in soft, mucky bottom land the combination of torque converter drive and unusual flotation ability permits the HD-20 to creep along without becoming mired down.

DIGGING AND LOADING — With the HD-20G, the operator crowds surely and steadily, using only throttle and bucket levers. With full horsepower always available even at creeping speed, he can work effectively in mud, on hillsides or the edges of banks.

let over a stationary piercing mandrel. By this process, it is theoretically possible to manufacture a tube of uniform wall thickness, roundness and surface finish. One imperfection or a combination of slight imperfections, however, produced into the pipe during fabrication serve positively to identify seamless pipe. Longitudinal spiraling internal mandrel scores in varying degrees of depth and quantity are found. Another defect appears as spiraling folds, called "seams," that can be found on either surface for any length along a joint of pipe. A third characteristic of seamless pipe may be nonuniform wall thickness that results when the inside diameter is not concentric with the outside diameter. The thick portion of the wall will always be diametrically opposite the thin portion.

Identifying Characteristics:

1. *Absence of a welded seam.*
2. *Longitudinal spiraling internal mandrel scores.*
3. *Spiraling internal or external folds (seams).*
4. *Eccentricity of ID to OD.*

Electric Resistance Welded Pipe

Electric resistance welded pipe is cold formed from long lengths of hot rolled sheet, called skelp, and then welded under pressure by heat from electric resistance without the addition of a filler metal. Two types come under this classification, each having its own characteristics. One type of resistance welded pipe currently made by one mill is formed into a tube in progressive pressing operations and welded instantaneously by a flash welding process. The principal identifying characteristic of this product is in the resulting upset weld. After welding, the flash is machined, leaving a keyed upset 1/32-in. to 1/16-in. high by 1/4-in. to 1/2-in. wide on both internal and external surfaces.

Identifying Characteristics:

1. *Uniform wall thickness.*
2. *Smooth internal and external surfaces.*
3. *Flat key upset on both weld surfaces.*

The second type of resistance welded pipe is formed on a series of forming rolls and electric resistance welded under stationary rolling electrodes as the pipe moves down the mill. The weld flash thus produced is completely trimmed off on both surfaces while still hot in an attempt to produce contoured surfaces flush with the contour of the pipe wall. Several irregularities are to be found in the weld zone to distinguish this type of manufacture. When new, the weld zone shows a characteristic metallic blue color where it has been heated. A worn electrode can cause a path of slight feathered electrode burns in the metal along both sides of the weld. Also, the internal flash trimmer cannot be controlled as easily as the external trimmer and may leave either a slight upset band at the weld, or gouge a shallow undercut at the internal surface of the weld.

Identifying Characteristics:

1. *Uniform wall thickness.*
2. *Smooth internal and external surfaces.*
3. *Slight upset or undercutting at internal weld surface.*
4. *Electrode feather burns along external weld zone.*

Electric Fusion Welded Pipe

Although there are several types in this classification, all are electric welded with the addition of a filler metal. The weld can be made manually, the practice at small shops, or it can be made continuously with automatic equipment. The tube may be formed with a longitudinal weld seam, or it may be formed spirally. All types exhibit the typical weld bead of filler metal.

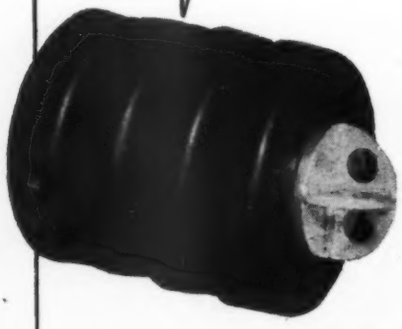
Identifying Characteristics:

1. *Uniform wall thickness.*

Williamson
pipeline pigs

Sizes 2" to 34"

- to separate dissimilar fluids
- to remove air from overbends
- to fill and empty pipelines . . . as for hydrostatic testing



COMPACT DESIGN — to traverse sharp bends. Cannot traverse conventional gate valves.

TYPE SBN-4 PIG

Proper cup spacing, as shown, is required for traversing gate valves.

Special Whistles, Rattlers and Radium Capsule Holders are available for Displacement and Batching Pigs.

TYPE LB-4 PIG

T.D. Williamson, Inc.

THE PIG WITH THE POKE
CLEANS PIPE LINES

P. O. BOX 4038
TULSA 9, OKLAHOMA

"There is a Pig design for your pipe-line problem."

REPRESENTATIVES . . . HOUSTON • PITTSBURGH • KENILWORTH, N. J. • AMARILLO
CASPER • PROVO, UTAH • LOS ANGELES • OAKLAND • EDMONTON • CALGARY
TORONTO • BUENOS AIRES • DURBAN, NATAL, SOUTH AFRICA

A section of Buckeye Pipe Line Company's dispatching center, which controls an intricate system of crude oil lines by teletype. William Flannery, at the teletypewriter, is communicating with a station on a change in pumping orders. J. R. McNeff, Chief Oil Dispatcher, talks with J. D. McCullough, Supt. of Communications, right.

Bell System Service helps Buckeye Pipe operate smoothly

Buckeye Pipe Line Company moves hundreds of thousands of barrels of crude oil and refined petroleum products daily in seven states. To keep lines operating smoothly, the company relies on 3000 circuit miles of Bell System Teletypewriter Service.

"The reliability of this service has been *99.5%*!" reports J. D. McCullough, Superintendent of Buckeye Communications.

This remarkable record of reliability has paid big dividends. Mr. McCullough adds:

"It has resulted in increased efficiency, considerable economy, and has maintained our reputation as a dependable, efficient carrier."

Bell System communications are an economy no pipeline operator can overlook. When you can get Bell System reliability, why tie up capital in communications equipment or set up reserves for maintenance and obsolescence?

We can furnish services to meet your exact requirements whether they are private-line telephone, mobile telephone, teletypewriter or channels for remote metering and supervisory control.

. . . . .

Your Bell Telephone Company will be glad to study your communications problems and needs without charge.

PRIVATE-LINE TELEPHONE

TELETYPEWRITER

MOBILE TELEPHONE

METERING CHANNELS

BELL TELEPHONE SYSTEM

2. *Smooth internal and external surfaces.*
3. *Prominent fusion weld bead present.*

Lap Welded Pipe

Lap welded pipe is made by heating the entire skelp and then forcing it over a mandrel with a pair of rolls embossed with a herringbone or knurled pattern. The pressure of the welding rolls completes a lap weld and also impresses a most distinctive herringbone or knurled pattern into the external surfaces of the pipe. Longitudinal scratches caused by the mandrel often can be found on internal surfaces and the lapped edge of the weld often can be seen on either surface as an irregular line, especially after a period of use under corrosive attack.

Identifying Characteristics:

1. *Prominent external herringbone or knurled pattern.*
2. *Internal longitudinal scratches.*
3. *Lapweld sometimes visible as irregular line on either surface.*

Butt Welded Pipe

Butt welded pipe has been made in sizes not exceeding 4½-in. OD by two different processes, loosely called "furnace welded" and "continuous welded." In furnace welded pipe, skelp with square cut or slightly beveled edges is heated to welding temperature in a furnace and then drawn through a funnel shaped die or through welding rolls into tubular form with sufficient edge pressure to make a welded seam.

Continuous welded pipe is the product of a more modern method of butt welding in that the skelp is drawn through a furnace from endless coils, the end of one coil being machine flash welded to the leading end of a new coil. The pipes produced by both methods are difficult to distinguish one from the other and either can be confused easily with seamless, unless carefully inspected.

Characteristic defects are few and not very pronounced when they do occur. Both types are smooth internally and externally with occasional external longitudinal scratches or feathered scratches adjacent to the weld. The straight weld usually can be seen down the length of the pipe on either surface varying from an almost invisible hairline to a prominent V-shaped notch.

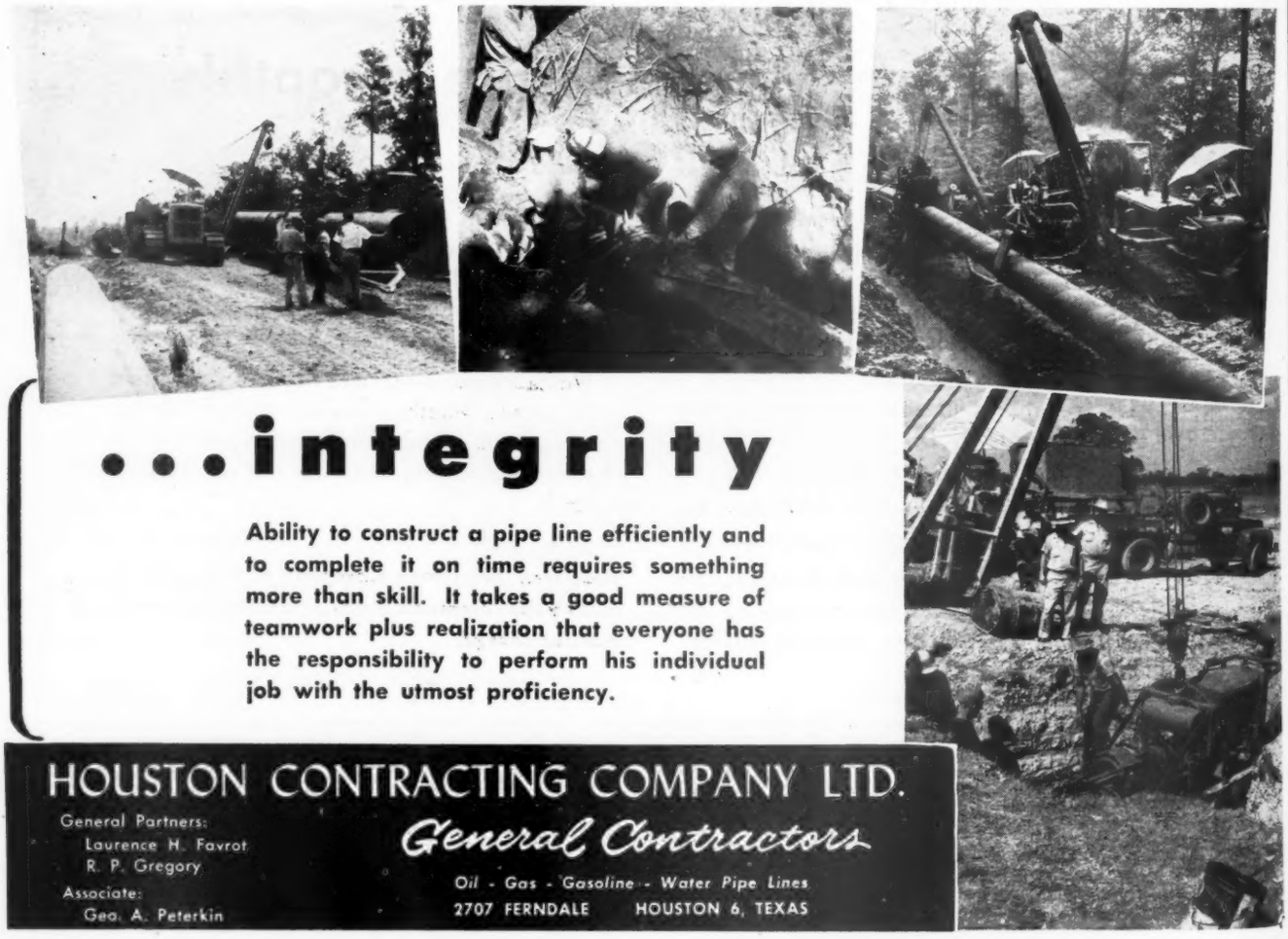
Identifying Characteristics:

1. *Smooth internal and external surfaces.*
2. *Longitudinal or feathered scratches adjacent to external weld.*
3. *Visible straight line weld internally or externally.* * * *

Welding Exposition Scheduled May 5-7 in Buffalo

American Welding Society will stage its second welding and allied industry exposition at the Memorial auditorium, Buffalo, New York, May 5-7. The society's National Spring technical meeting will be held at Hotel Statler in the same city, May 4-7.

Society's first show, held in Houston, Texas, last year, attracted key executives from more than 20 industrial fields. The Buffalo exhibit will be almost twice as large and the attendance is expected to be more than three times as great. More than 100 exhibitors are expected and products of more than 300 companies will be shown.



...integrity

Ability to construct a pipe line efficiently and to complete it on time requires something more than skill. It takes a good measure of teamwork plus realization that everyone has the responsibility to perform his individual job with the utmost proficiency.

HOUSTON CONTRACTING COMPANY LTD.

General Partners:
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Associate:
Geo. A. Peterkin

General Contractors

Oil - Gas - Gasoline - Water Pipe Lines
2707 FERNDALE HOUSTON 6, TEXAS

longer lines

longer pipes

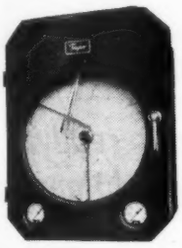
Control Problems?

more powerful driving units

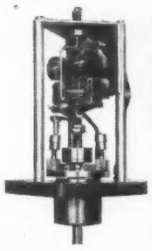
unattended stations

WITH today's longer lines, larger pipes, more powerful driving units, and unattended stations, pipe-line installations must be precisely controlled. Many operators have proved that maximum efficiency is obtained when conditions are regulated by Taylor instruments specifically designed for their control.

Whatever the control required, there is a Taylor instrument to provide it. Pressure, engine speed, flow, specific gravity, temperature—all these factors yield themselves to precise regulation with Taylor instruments. Call your Taylor Field Engineer, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.



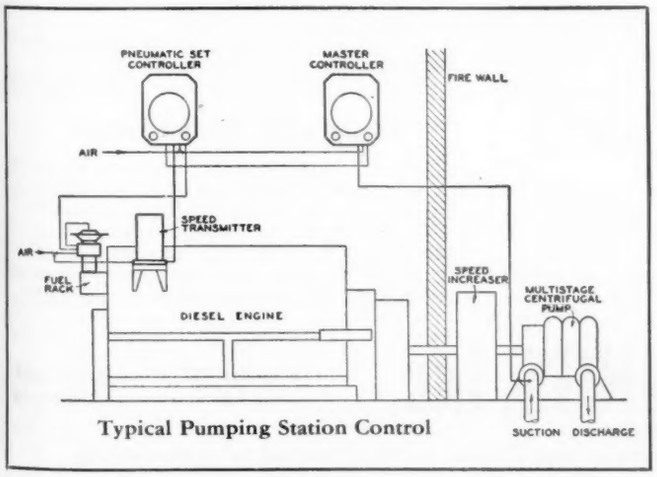
Taylor FULSCOPE* Master Pressure Controller controls both suction and discharge pressures—whichever requires regulation as loads vary. It directs pressure conditions at each pumping station regardless of the type of product flowing through the lines. Operating in conjunction with the FULSCOPE Speed Controller and Speed Transmitter, the Master Pressure Controller is ideal for both liquid and gas lines and with any type of driver. It can be adapted to position control valves and to adjust engine speed—typical requirements at electrically powered installations. **The Taylor FULSCOPE** Pressure Controller — because of its flexibility—can easily be adapted to the control of practically any variable in pipeline operation. It is famous throughout industry for simplicity and dependability.



Taylor Pneumatic Speed Transmitter offers an accurate and efficient method of measurement and pneumatic transmission for the control of speed on compressors, pumps, or engines . . . or on applications where the process variable is equipment speed. **Convenient Direct Speed Readings** are recorded on a squareroot chart or scale. **Direct-Set Speed Feature:** The engine speed can be easily and quickly varied manually, by turning a knob on the receiver controller, or automatically by the Master Pressure Controller. **High Accuracy:** Output air pressure is proportional to the square of measured speed accurate to 0.03 psi. **Great Flexibility:** Only top speed needs to be determined. Selection of fly-weight speed 600 to 1500 rpm. Output air pressure of unit from zero to top speed produces an output air pressure of 3 to 15 psi.

FOR MORE COMPLETE OPERATION

Flow control is available for station automatic start-up or shutdown and can be used as an override control in conjunction with the Master Pressure Controller. . . . Specific gravity measurement is used to detect changes of fluid composition in the pipe lines. The signal received can be employed automatically to adjust station operating pressure or flow. . . . Temperature control is available for cooling water, lubricating oil, or safety shutdown. Write for more details.



Typical Pumping Station Control

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

*Reg. U.S. Pat. Off.

Taylor Instruments

MEAN

ACCURACY FIRST

IN HOME AND INDUSTRY

of interest to you!

More than 101,000,000 SQ. Ft. of Steel Pipe Protected by SOMASTIC® Pipe Coating!

First choice for permanence under really tough corrosive conditions

PERFORMANCE PROOF AVAILABLE!

Read these typical highlights...

Examination of longest and oldest continuous mastic application to a product pipe line in the Mid-Continent area . . . after 9 years of service. *(Extracted from "Examination of 335 Miles of Asphalt Mastic Coated Pipe," by Donald E. Miltner, published in July, 1953 Corrosion, publication of the National Association of Corrosion Engineers.)*

"The 335 miles of 6⅝ inch OD pipe line extends from Topeka, Kansas, to Sioux Falls, South Dakota. A lightweight pipe of 14.96 pounds per foot was used in this construction because the line was to be coated in its entirety and in addition maintained under cathodic protection. This weight of pipe was selected to allow an adequate factor of safety for the normal range of operating pressures and yet provide for maximum economy in overall investment costs. Five cathodic protection rectifier units were installed soon after construction of the line was completed.

"The three principal methods used to examine the nine year old coating were:

1. A modified Pearson coating discontinuity survey.
2. Inspection of a representative number of indicated coating failures.
3. Coating conductance measurements on isolated sections of the gross structure.

Results. "This survey indicates that the inspection made of the coating during manufacture and construction of the line was of a high order.

"The rate of discontinuities was found to be one per four miles of pipe line. This exceedingly low rate substantiates the high quality of the coating found in the examination.

"The coating was almost completely unaffected by soil stress with the whitewash largely intact.

"The low discontinuity rate per mile and small area of affected coating shows that moderate protective voltages have not affected the sound coating for at least nine years.

"The total area of coating adversely affected from any cause whatsoever was approximately 50 square feet in over 3 million square feet of pipe coating."

Conclusion (ours!) 50 square feet of coating adversely affected out of 3 million square feet after nine years is a *remarkable* record!

When you buy pipe to resist really tough corrosion . . . confidence is of the utmost importance.

SOMASTIC Coated Pipe will give you that confidence. The pipe coating identified by the registered trade-mark SOMASTIC, is a dense mixture of asphalt-mastic...applied as a continuous, uniform, seamless protective sheath. Desired mechanical strength and other physical properties for each project are secured by properly grading inert materials, and combining them with the optimum amount of the correct grade of asphalt. Waterproofing is assured. The completed, coated pipe withstands stockpiling, field hauling and handling methods that will rupture or distort other coatings.

As to permanence in the ground . . . our knowledge of the useful life of SOMASTIC Coated Pipe still is limited only by the total time it has been in existence . . . and it has been on the market since 1934.

So . . . why not check on SOMASTIC Pipe Coating the next time you need corrosion protection in *your* pipe line?

Do you want the full story?

Write TODAY for the complete story of this field examination of SOMASTIC Pipe Coating. Ask for "335 Mile Report."

If you wish, we will also send you other field test reports and a list of SOMASTIC Pipe Coating user references near you. We are at your service!

SOMASTIC Pipe Coating is manufactured and applied in the 11 Western States and All Foreign Locations by . . .

PIPE LININGS, INC.

2414 East 223rd St., Wilmington, Calif.

P. O. Box 457, Wilmington, Calif.
Rail Address: Watson, California

A Service Organization Specializing in SOMASTIC Pipe Coating and in the Interior Lining of Pipe by the Tate Process and the Centriline Process.

PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
CRUDE LINES				
California-Oregon Pipe Line System	103	6	Crescent City, California to Medford, Oregon.	Proposed
Cities Service Pipe Line	60	12	Houston to Sour Lake, Texas.	Planned
Gulf Refining	55	12	Bay Marchand to Plaquemines, Louisiana.	Planned
Interprovincial Pipe Line Company	600	24–26	Loops–between Edmonton, Alberta, and Superior, Wisconsin.	Proposed
Magnolia Pipe Line Co.	29	8	Midland County, Tex. area	Planned
	56	8	Gaines County, Texas, to Lea County, New Mexico.	H. B. Zachry
Michi, Incorporated		10	Highland, Ind., to Kalamazoo, Alma, and Elsie, Mich.	Planned
Omaha-Denver Express Company	65	—	Little Beaverfield to Denver, Colorado	Proposed
Pasotex Pipe Line Co.	146	10	Snyder to Wink, Texas	Planned
Phillips Pipe Line Company	18	—	Gathering lines, northeast area of Andrews County, Texas.	Under way
Powder River Pipe Line Company	52	6–8	Gathering lines, near Kaysee, Wyoming.	Planned
Progress Pacific Pipeline Company	1100	24	Odessa, Texas, to Los Angeles, Harbor, Cal.	Planned
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.	Planned
Roosevelt Oil & Refining Corp.	22	4, 6	St. Helen to Norwick, Michigan.	Planned
Service Pipe Line Company	55	4–6–8	Tioga-Beaver Lodge area gathering system.	C. P. Bartley & Son
Sinclair Pipe Line Company	10	12	Pauls Valley to Bradshaw Gate Plant, Okla. (Loop).	Planned
Sioux Pipe Line System	1000	16 to 24	Williston Basin to Chicago.	Under consideration
Texas New Mexico Pipe Line Company	52	10	Dawson County to Basin Saystem.	McVean & Barlow
Texas Pipe Line Co.	34	6	Sour Lake to Port Arthur, Tex.	Houston Contracting
Texas Pipe Line Co.	45	8–10	Erath and Bayou Sale sta.	Houston Contracting
Texas Pipe Line Co.	65	4–6–8–12	South Louisiana.	Panama-Williams
Trans Mountain Oil Pipe Line Company	26	16, 24	Sumas to Ferndale, Washington.	Planned
West Coast Pipe Line Company	960	20–22	Wink, Texas to Norwalk, California.	Planned
PRODUCTS LINES				
American Pipe Line Company	1910	8 to 26	Beaumont, Tex., to Newark, New Jersey, with laterals.	Proposed
Augusta Pipe Line Company	43	8	Arkansas City to Augusta, Kansas.	Ray L. Smith & Son, Inc.
Badger Pipe Line Company	215	8–10–12	East Chicago, Indiana to Madison, Wisconsin.	Begin Spring '54.
Bell Oil & Gas Co.	150	6–8	Ardmore to Drumright, Okla.	Proposed
H. W. Bass & Sons, Incorporated	152	4–6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas.	Proposed
Frontier Refining Company	—	6	Cheyenne, Wyoming to Grand Island, Nebraska	Planned
Great Lakes Pipe Line Company	130		Nebraska City to Grand Island, Nebraska.	Proposed
Harbor Products Systems	86	16	Woodbury Junction, Philadelphia to Trembley Point, New Jersey.	Construction Service Co. and H. C. Price Co.
International Pipe Line Inc.	132	8	Wrensball to Minneapolis, Minnesota.	Proposed
Oklahoma Mississippi River Products Line,	475	12	West Memphis, Arkansas to White River.	Williams Bros. 12–31–53.
Oklahoma Mississippi River Products Line,			White River to Duncan Oklahoma.	River Construction Co. Completion date 6–30–54.
Phillips Petroleum Company	54	6	Goldsmith to Borger, Texas.	Planned
	52	10	Shell's Brookshire system to Sweeney, Texas.	Planned
Salt Lake Pipe Line Company	40	6	Adams, Oregon, to Pasco, Washington (Loop).	Planned
Shamrock Oil & Gas Corporation	55	6	McKee to Amarillo, Texas.	Planned
Triangle Pipe Line Company	560	12	Arkansas City, Arkansas, to Covington, Kentucky, and Nashville, Tennessee.	Proposed
United States and Canadian Government	600	8	Haines to Fairbanks, Alaska.	Underway
United States Pipe Line Company	1799	22–26	Beaumont, Texas to Newark, New Jersey.	Proposed
Williston Basin Pipe Line Company	244	8	Laurel-Billings, Montana refineries to Glendive, Mont.	Proposed
Yellowstone Pipe Line Company	540	10	Billings, Mont., to Spokane, Wash. (Continental Oil Co., Interstate Oil Pipe Line Co., Union Oil Co., and H. Earl Clack interest).	To be completed 9–54.
Yellowstone Pipe Line Company			Billings to Bozeman, Montana.	Ross and Powers
Yellowstone Pipe Line Company			Bozeman to Helena and on to Clinton, Montana.	Associated Pipe Line Contractors, Inc.
Yellowstone Pipe Line Company			Clinton to Perma, Montana.	Associated Pipe Line Contractors, Inc.
Yellowstone Pipe Line Company			Clinton to Perma, Montana.	Eastern Pipe Line Fields Service Co.
Yellowstone Pipe Line Company			Perma, Montana, to Murray, Idaho.	Eastern Pipe Line Field Service Co.
Yellowstone Pipe Line Company			Murray, Idaho to Spokane, Washington.	Engineers Limited Pipe Line Company.

Name of Company	Miles	Pipe size, in.	Location	Contractor
GAS LINES				
American-Louisiana Pipe Line Company	1000	30	Lowry, Louisiana to Detroit, Michigan.	Proposed
Arkansas-Louisiana Gas Company	107	8⅝ to 24	Nine Loops on System.	Planned
Arkansas-Missouri Power Company	140	2 to 10	St. Francis River, Clay County, Ark. to near Campbell, Missouri.	Planned
Associated Natural Gas Company	88		Missouri.	Proposed
Atlantic Seaboard Corporation	29	26	Looping along Cobb-Rockville, Maryland, line.	Proposed
Carolina Natural Gas Corporation	185	2–12	Lateral lines off Transcontinental in North and South Carolina.	Proposed
Chicago District Pipe Line Company	31	20–30	Chicago area.	Proposed
Cities Service Gas Company	18	16	Lawrence and Newton Counties, Missouri.	
Cities Service Gas Company	69	20–16	Cleveland, McClain and Garvin Counties, Okla.	Planned
City of Fayette, Alabama	20	5	Fayette, Ala. to Southern Natural's system in Tuscaloosa County, Alabama.	Proposed
City of Dallas, Georgia		8, 4½	Distribution system.	Engineering-Construction Company, 1954.
Coast Counties Gas & Electric Company	40	3, 4, & 8	Coast and Valley Region, California.	Planned
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado.	Planned
Colorado Interstate Gas Company	243	4 to 20	Colorado, Oklahoma, Texas, and Kansas.	Engineering-Construction and Z. J. Graham
Colorado-Western Pipeline Company	454	—	S. W. Colorado fields to Denver area.	Planned
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia.	Proposed
El Paso Natural Gas Company	771	30	Plains, Texas to Kingman, Arizona.	Under way
El Paso Natural Gas Company			Section 1—Plains, Texas to Corona, New Mexico.	Oklahoma Construction Company
El Paso Natural Gas Company			Section 2—Corona to Suwanee, New Mexico.	R. H. Fulton
El Paso Natural Gas Company			Section 3—Suwanee to Gallup, New Mexico.	R. H. Fulton
El Paso Natural Gas Company			Section 4—Edge of Navajo Reservation east to Flagstaff on to Kingman, Ariz.	Western Pipe Line Construction, Inc. Completion date 2–54.
El Paso Natural Gas Company			Across Navajo Reservation connecting sec. 3, 4 and 5.	El Paso Company crews
Fort Worth Basin Gas Company	—	—	Novice, through Brown and Comanche Counties, Tex.	Planned
Glacier Gas Company	285	20	Kalispell, Montana, to Spokane, Washington.	Proposed
Glacier Gas Company	120	16	Spokane to Hansford, Wash.	Proposed
Glacier Gas Company	91	8⅝	Spokane to Lewiston, Idaho.	Proposed
Glacier Gas Company	130	12¾	Spokane to International boundary at Trail, British Columbia.	Proposed
Gulf Interstate Gas Company	860	30	Acadia Parish, Louisiana, to Boyd County, Kentucky.	H. C. Price and Houston Contracting. 11–54
Gulf Interstate Gas Company	230		Gathering lines.	Associated Pipe Line Contractors, Anderson Bros., Williams Bros.
Gulf Interstate Gas Company	329	12–24	Laterals off Acadia Parish, Louisiana, to Boyd County, Kentucky, line.	Proposed
Home Gas Company	32	12	Breesport to Union Center, New York.	Planned
Home Gas Company	22	12–.6	Binghampton, New York.	Under way
Houston Texas Gas & Oil Company	1200	30	Louisiana to New York.	Proposed
Interstate Power Company	26	8	From National Gas Pipe Line Co. of America, line near Hooppole, Illinois to Clinton, Iowa	Proposed
Kansas-Nebraska Natural Gas	41	10	Albion, Arcadia, and Brokee Bow, Nebraska.	Proposed
Lone Star Gas	100		Proposed storage fields to Dallas-Ft. Worth area.	Proposed
Lone Star Gas	35	12	Southeastern Schleicher County.	Proposed
Lone Star Gas	36	12	Stamford to Abilene, Tex.	Planned
Lone Star Gas	44	12	Red Springs, Woods County to Sulphur Springs area, Hopkins County, Texas.	Under way
Manufacturers Gas Light & Heat	40		Alegheny, Washington, and Beaver Counties, Pa.	Proposed
Manufacturers Gas Light & Heat	213	3 to 16	Various points on system in Pa., West Vir. and Ohio.	Proposed
Manufacturers Gas Light & Heat	72	16–20	Doddridge, Wetzel and Marshall Counties, West Vir.	Proposed
Mississippi River Fuel Corporation	190	10–18	Laterals in Woodlawn and Waskom gas fields, Tex.	Planned
Missouri Central Gas	25	6	Moberly to Macon, Mo.	L. R. Young Construction
Missouri Public Service	136	8–10	New Franklin to Trenton, Missouri.	Proposed
Missouri Public Service	24	10	Johnson County to Clinton, Missouri.	
Montana Power	52	16	Canada-Montana border to Cut Bank, Montana.	Planned

PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky.	Planned
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado.	Planned
New River Gas	50		Summers to Montoe counties, West Vir. to Narrows and Dublin, West Vir.	Planned
North Dakota Natural Gas Company	500	10-12	Statewide system in North Dakota.	Planned
Northeastern Gas Transmission	22	8	Upton, Massachusetts to Pawtucket, Rhode Island.	Planned
Northern Indiana Fuel & Light	35	8	Edgerton to Alburn, Indiana.	Planned
Northern Natural Gas	458		Kansas, Texas, Oklahoma, and Nebraska, Iowa and Minnesota, to connect with Permian Basin System.	Proposed
Northern Natural Gas	475		Proposed branch lines to Iowa, Neb., Minn. and and South Dakota.	
Northwest Alabama Gas District	40	9	Southern Natural's line through Winfield to Haleyville, Alabama.	Proposed
Northwest Natural Gas	750	24	Eastport, Idaho, to Monroe, Washington.	Planned
Northwest Natural Gas		18	Monroe to International boundary near Lynden, Washington.	
Northwest Natural Gas		22	Monroe to near Seattle, Washington.	
Northwest Natural Gas		20	Seattle to Portland, Oregon.	
Ohio Fuel Gas	31	20	Licking County to Richland County, Ohio.	Planned
Ohio Fuel Gas	22	16	Dayton, Troy, Piqua and Sidney, Ohio.	Planned
Ohio Fuel Gas	23	16-20	Wellington to Elyria, Ohio.	Planned
Ohio Fuel Gas	16	20	Benton Station to Crawford Station.	Planned
Ohio Fuel Gas	18	20	Crawford Station to near Columbus.	
Ohio Fuel Gas	16	16	Berlin to Sandusky, Ohio.	Planned
Ohio Fuel Gas	74	3 to 20	Hocking, Knox, and Ashland counties, Ohio.	Planned
Ohio Fuel Gas	47	20	Benton Township, Hocking County, to Columbus, Ohio.	Planned
Ohio Fuel Gas	61		Northern and southwestern Ohio.	Planned
Ohio Fuel Gas	33	20	Jefferson to Seneca, Ohio.	Proposed
Ohio Fuel Gas	69	20-24	Lines to tie in Gulf Interstate line along various points in Lawrence, Jackson, Vinton, Hocking and Fairfield counties, Ohio.	Proposed
Pacific Gas & Electric	50	12-16-20	Fresno to Merced, Cal.	Planned
Pacific Gas & Electric		20	Holm to Topock-Milpitas line—Section 2.	
Pacific Gas & Electric		12	Section 3—Parallel existing Madera Livingston line, planned. Napa Wye to Shellville, Cotati to Santa Rosa, California.	
Pacific Gas & Electric	129	31	Main-line loops along Topock, Arizona, to Milpitas, California.	Completion date 11-54 Proposed
Pacific Gas & Electric	88	34	Portions of 34 in. Topock-Milptas pipe line.	Completion date 4-15-54.
Pacific Northwest Pipeline Corp.	1466		Ignacio, Colorado, to Bellingham, Washington.	Proposed
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off mail line to Pocatello, Idaho to Yakima, Washington.	Proposed
Permian Basin Pipeline Company	280	16-24-26-30	West Texas and New Mexico.	R. H. Fulton & Company
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York.	Proposed
Shenandoah Gas Company	39	3-4-8	Middleton Virginia, to Martinsburg, West Vir.	Proposed
South Georgia Natural Gas Company	339	2-12	Phoenix, Alabama to Tallahassee, Florida.	Planned
Southwest Gas Corporation, Limited	26	—	From P.G. & E. line to Victorville, California.	Proposed
Tennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut.	Planned
Tennessee Gas Transmission	28	30	White Plains, New York to Newark, New Jersey.	Planned
Tennessee Gas Transmission	571	30	Kinder, Louisiana to Portland, Tennessee.	Approved
Tennessee Gas Transmission	67	30	Loops in Texas and Louisiana.	Approved
Tennessee Gas Transmission	63	26	Loops in Ohio and Pennsylvania.	Approved
Tennessee Gas Transmission	58	20	Louisiana Gulf Coast to Station No. 507 near Kinder, Louisiana.	Approved
Tennessee Gas Transmission	100		Laterals in Texas.	
Tennessee Gas Transmission	45	20	Buffalo, New York to the U. S.-Canadian border, Hamburg station near St. Catherines.	Approved
Texas Eastern Penn-Jersey Transmission Corporation	265	24	Oakford storage field to Lambertville, New Jersey.	Planned
Texas Gas Transmission Corporation	48	26	Loops on Memphis-Slaughter line.	Planned
Transcontinental Gas Pipe Line Corp.	533	30-36	Loops on Texas-New York main line.	Planned
Trans-Northwest Gas Inc.	246	—	International Boundary near Osoyoos, British Columbia to Washington and Idaho.	Proposed
Trans-Northwest Gas	275	—	Branch lines.	Proposed
United Gas Fuel, and Central Kentucky Natural Gas	92	—	Gulf Interstate system, Boyd County, Kentucky to Putman County, West Virginai.	Proposed
United Fuel Gas	50	20-24	Wood County to Hanham, West Virginia.	Proposed. Spring 1954
United Fuel Gas	32	24	Near Ripley, West Virginia to Lanham station, Putman County, West Va.	Proposed
United Fuel Gas	60	30	Lanham in Kanawha County, West Va., to Gulf Interstate line in Boyd County, Kentucky.	Proposed
United Gas Pipe Line	44	20	Lirette field to Harvey, La.	Brown & Root
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania.	Planned
Utah Natural Gas Company	103	16-18	Clear Creek field near, Price to Salt Lake City, Utah.	Proposed
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.	Proposed
Warren Petroleum	54	4-30	Lea County, New Mexico.	Planned
Warren Petroleum	23	3 to 20	Garvin County, Oklahoma.	Completion date 6-54.

FOREIGN CRUDE LINES

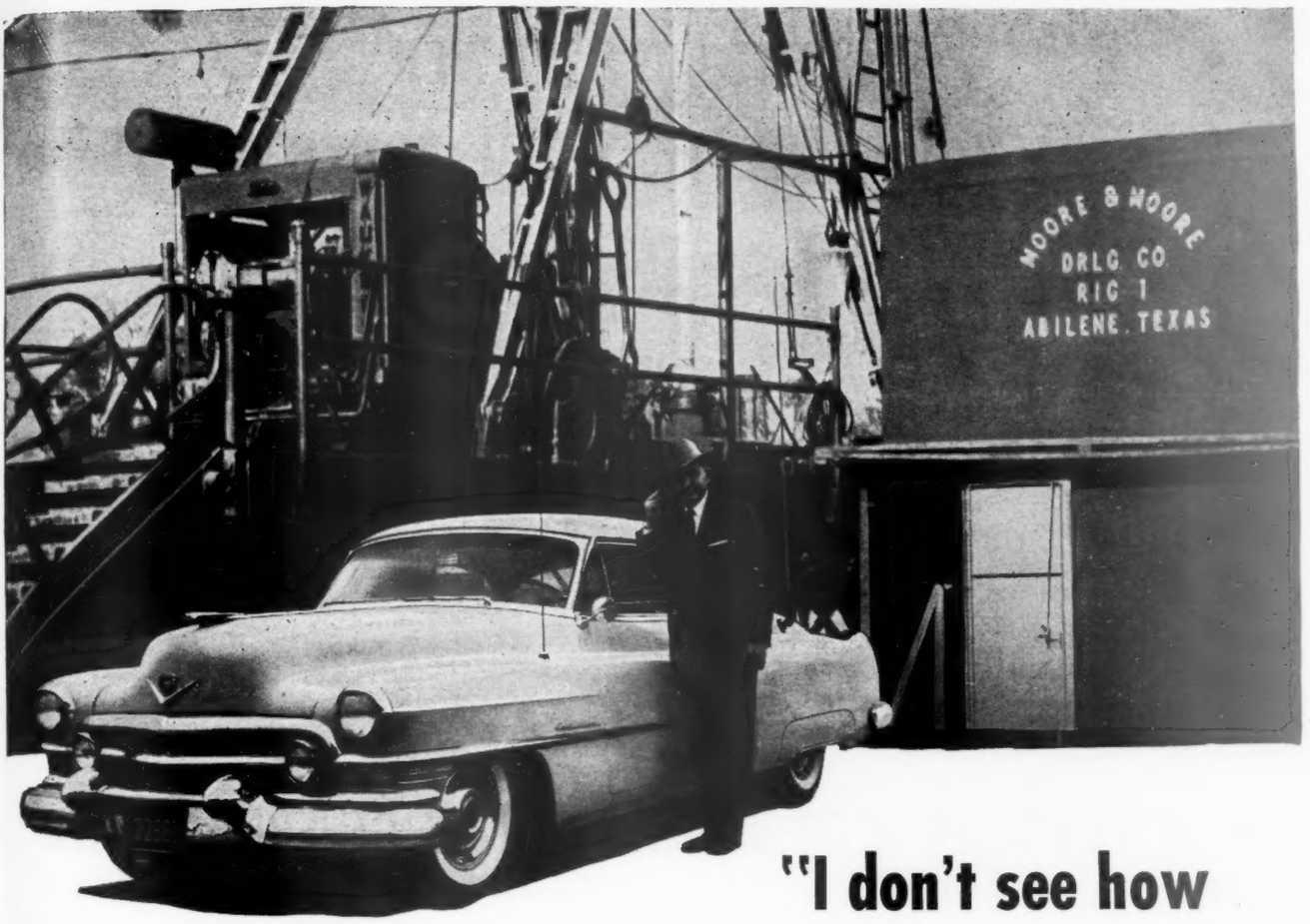
Arabian American Oil Company	18	22-20	Qatif to Ras Tanura No. 3.	Completion date 1-55.
Bombay Port Trust	50	8 to 24	Bombay, India, to serve Standard Vacuum Oil Co. and Burmah Shell refineries.	Merritt, Chapman and Scott Corp. contractors. (Crude and products).
Creole Petroleum Corporation	25	34	Lagunillas to La Salina (State of Zulia, Venezuela)	Planned
Direction General de Yacimientos Petroliferos Fiscales	400		Plaza Huincul to Bahia Blanca, Argentina.	Under way
Petroleos Mexicanos	145	12	18 de Marzo field via Raynosa to Monterrey, Mexico.	Considered
Petroleos Mexicanos	100		Isthmus of Tehuantepec, Jose Colomo to El Plan field, Minatitlan.	
Petroleos Mexicanos	72	12	Poza Rica to Atzacapotzalco, Mexico.	Proposed
Petroleos Mexicanos	125	10	Jose Colomo to El P n, Mexico.	Under way
Saskatoon Pipe Line, Limited	56	6	Milden to Saskatoon, Saskachewan, Canada.	Planned
Texas Petroleum Co.	60	4-6	Pta. Nio to La Dorada.	Under way
Yacimientos Petroliferos Fiscales Bolivianos	170	4	Bermejo to Tupiza, Bolivia.	Planned

FOREIGN PRODUCT LINES

Anglo-Iranian Oil Company, Ltd.	18½	16	Little Aden to Aden, Bechtel.	Bechtel Corporation. Completion 12-54.
Anglo-Iranian Oil Company, Ltd.	15	12	Kwinana to Fremantle.	M. W. Kellogg Company. Completion date Feb., 1955.
Anglo-Iranian Oil Company, Ltd.	17	6	Kwinana to Fremantle.	M. W. Kellogg Company Completion date Feb., 1955.
Columbian Ministry of Petroleum	115	4	La Dorado to Cartago, Columbia.	Williams Brothers Engineers.
Columbian Ministry of Petroleum	93	8	Cantimplora to Dorado, Columbia.	Williams Brothers Constructors.
Empresa Nacional del Petroleo	80	6⅝	Concon to Santiago, Chile.	Planned
Governments of Southern Rhodesia and Portuguese E. Africa	200		Beria, Portuguese Mozamque to Umtalia, Southern Rhodesia.	Considered
North Atlantic Treaty Organization (NATO)	1920	4-10	To serve military bases in Western Europe (to connect with U. S. Government's St Nazaire-Paris Metz line).	Contracted by Soc. Foster Wheeler Francais.
Petroleos Mexicanos	124	6	Lagos to Guadalajara, Mex.	Planned
Petroleos Mexicanos	54	6	Lagos to Aguascalientes, Mexico.	Planned
Petroleos Mexicanos	82	8	Salamanca to Lagos, Mex.	Planned
United States Government	375	12	St Nazaire to Melun and Metz, France.	Planned

FOREIGN GAS LINES

Azienda Generale Italiana Petroli	90	12	Cortemaggiore to Bologna, Italy.	SNAM crews
Azienda Generale Italiana Petroli	120	16	Cremona Porto Mar to Ghera, Italy.	Montubi, Contractor
Azienda Generale Italiana Petroli	40	12	Rapalta-Bergamo, Italy.	
Dirrecion General del Gas del Estado	310	8	Plaza Huincul to Neuquen, Argentina, to the vicinity of General Conesa, Argentina.	
Empresa Nacional del Petroleo	80	10	Concon to Santiago, Chile.	Planned
Mid-Continent Pipelines, Ltd.	1860	30	Alberta to Montreal, Canada.	Fish Engineering Co.
Northwest Natural Gas Company	950	24	Alberta fields to Vancouver, British Columbia, Seattle, Washington and Portland, Oregon.	Planned
Petroleos Mexicanos	205	16	Monterrey to Torreon, Mex.	Under way
Petroleos Mexicanos	440	20	Brazil to Tampico to Poza Rice, Mexico.	Planned
Trans-Canada Pipe Lines, Ltd. (Canadian Delhi Oil Co.)	2247	14-30	Alberta to Toronto to Montreal.	Proposed
Trans-Canada Pipe Lines, Ltd. (Canadian Delhi Oil Co.)	747	8-24	Gathering system in Alberta.	



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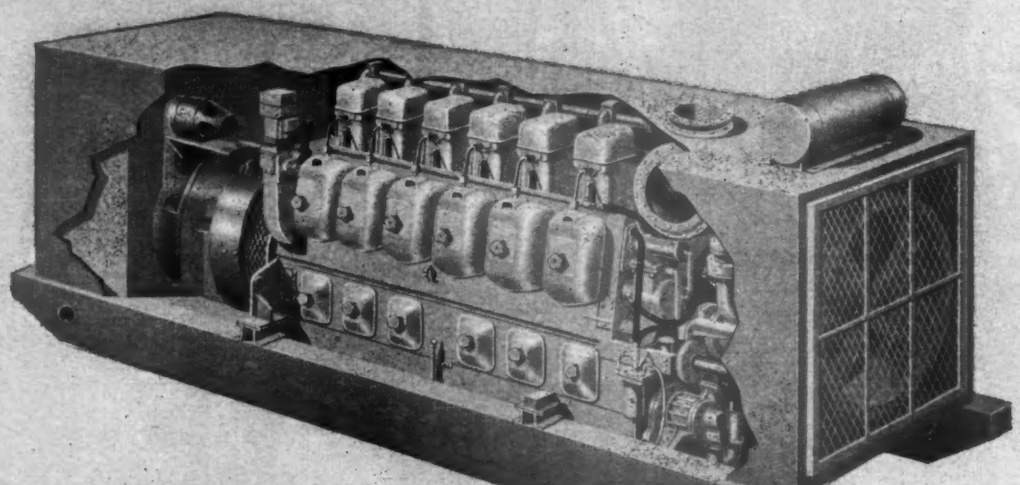

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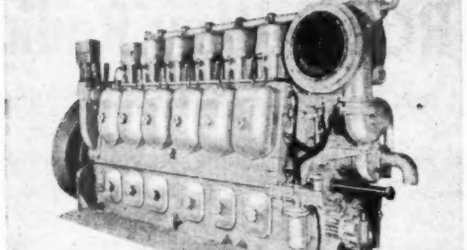

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PIPE LINE PROJECTS

Four Apply Jointly On American-Louisiana Line

Four interdependent applications — including a proposal by American Louisiana Pipe Line Company, of Detroit, Michigan, to build a Louisiana-to-Michigan pipe line — requesting authority for the construction of natural gas transmission facilities have been filed with the FPC.

In addition to American Louisiana, the filing companies are Texas Gas Transmission Corporation, of Owensboro, Kentucky; Michigan-Wisconsin Pipe Line Company, of Detroit; and Michigan Consolidated Gas Company, also of Detroit. American Louisiana, Michigan-Wisconsin and Michigan Consolidated are subsidiaries of the American Natural Gas Company.

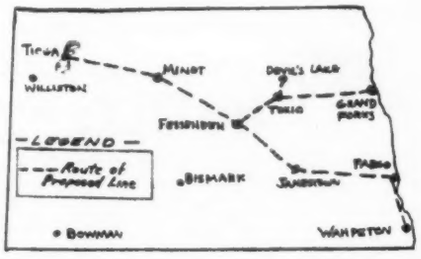
American Louisiana, a newly-formed company, is proposing to construct approximately 1,289 miles of pipe lines at an estimated cost of $130,000,000. The proposed system would include 30, 24, 22, 8 and 6-in. pipe and three compressor stations of 10,000-hp each. The 30-in. portion of the line would extend from North Tepetate, Acadia Parish, Louisiana, to a point of connection with Michigan Consolidated's facilities near Detroit. The 22-in. portion of the system would extend from a point on American Louisiana's proposed 30-in. lines near Payne, Ohio, to a point of connection with Michigan-Wisconsin's system near Bridgman, Michigan. The 24-in. and the smaller size pipe will feed gas into the 30-in. line at North Tepetate.

American Louisiana proposes to purchase an average of 51,000,000 cu ft of gas per day from Texas Gas at a connection near Slaughters, Kentucky. The system would have an initial capacity of about 300,000,000 cu ft per day, with an average of 255,700,000 cu ft being purchased from various fields in southern Lousiana. The gas would be made available to all markets served by the American Natural Gas Company system, which also includes the Milwaukee Gas Light Company.

Texas Gas is seeking authority to build about 48 miles of 26-in. pipe line, paralleling sections of the company's existing system between its Lake Cormorant, Mississippi, compressor station and its Slaughter, Kentucky, compressor station. The project also would include one additional 1500-hp compressor at the Covington compressor station, and a sales meter station near Slaughters for the proposed sale of natural gas to American Louisiana. Estimated cost of the project is $4,281,135.

Michigan-Wisconsin is proposing to construct approximately 251.9 miles of 24, 18, 12, 6 and 4-in. pipe line loops and 3400 additional horsepower at existing compressor stations, principally in Illinois. The company is proposing to purchase about 100,000,000 cu ft of gas per day from American Louisiana to meet present and future requirements of the markets which it serves. The new facilities have a total estimated cost of $11,435,000.

Michigan Consolidated plans to build facilities in connection with proposed operation of the Six Lakes field, in Mecosta and Montcalm counties, Michigan, as a storage field. The construction includes a 32,000-hp compressor station in the field; a station located near Detroit to receive about 200,000,000 cu ft of gas per day from American Louisiana; and about 25.5 miles of 12-in. pipe line extending from a point of connection with Michigan-Wisconsin's facilities near Sparta to Muskegon, Michigan. Michigan Consolidated estimates that the Six Lakes field, when fully developed, will have a total storage capacity of approximately 66 billion cubic feet and a working storage capacity of about 53 billion cubic feet. Total estimated cost of Michigan Consolidated's project is $12,745,900.



ROUTE OF a new 607-mile, $12,500,000 natural gas pipe line planned for North Dakota by North Dakota Natural Gas Transmission Company. Gas will come from Signal Oil and Gas plant at Tioga, completely processed. Application has been made to North Dakota's Public Service Commission for permit to build and operate the line, which will be wholly an intrastate operation.

Alabama-Tennessee Gas Planning Expansion

FPC has authorized Alabama-Tennessee Natural Gas Company of Florence, Alabama, to construct facilities to increase the capacity of its natural gas transmission system by about 8,466,000 cu ft of natural gas per day, from the presently authorized 32,196,000 cu ft to a total of 40,662,000 cu ft.

At the same time the FPC authorized Tennessee Gas Transmission Company to increase its deliveries to Alabama-Tennessee by 8,466,000 cu ft daily. Additional gas will be made available to Alabama-Tennessee's existing customers in Alabama, Tennessee, and Mississippi.

Alabama-Tennessee will construct about 13.2 miles miles of 12 and 8-in. loop pipe line, together with a 350-hp compressor station, in Colbert County, Alabama. Estimated cost of the project is $440,196. Tennessee will not have to construct any new facilities to increase its deliveries to Alabama-Tennessee.

Goodall Pipe Line System Dedicated

A 41-mile, 6-in. pipe line costing $1,100,000 has gone into operation in northeastern Colorado. Tapping three major fields in the area, the Goodall Pipe Line will deliver 20,000 bbl daily from the Little Beaver, Badger Creek, and Middlemist fields. Terminal for the new system is Merino, in Logan County.

Saskatchewan Line Plans Revised

Saskatchewan Power Corporation's plans to build a 40-mile, 10-in. gas pipe line in 1954 to tie in the Coleville gas field with the existing Brock-Saskatoon 10-in. line, will be held up pending a fuller outline of the field. Recent extensions of the field brought the change in plans.

Consumers have been signed up far ahead of expected volume and reserves originally allocated from the Brock field are not adequate for next winter. Reserves to be drawn on for 1954-55 winter season will have to be developed in the next few months from the St. Florence, Marengo, and Glidden discoveries, company has indicated.

Northern Natural OK'd On New Facility Operation

FPC has issued a certificate to Northern Natural Gas Company, of Omaha, Nebraska, authorizing the operation of pipe line facilities which will make additional natural gas available this winter to customers serving market areas in the Midwest.

The Commission's action authorizes Northern to operate these first-year facilities, which include about 259 miles of 24 and 30-in. pipe and a total of 50,400-hp in compressor capacity, located in Texas, Oklahoma, Kansas, Nebraska and Iowa. Estimated cost of construction is $33,273,000. The commission also granted a certificate for certain branch-line loops to enable Northern to deliver the additional gas during the current winter. Temporary authorization for this construction was granted last October. These facilities will increase the capacity of Northern's system by 200,000,000 cu ft per day, with the sales capacity increased by about 186,000,000 cu ft daily.

Texas Eastern Plans Gas Storage Service

Texas Eastern Transmission Corporation and a wholly owned subsidiary have filed applications with the Federal Power Commission for approval of a project involving a "gas storage service" for Transcontinental Gas Pipe Line Corporation. Under the plan, Texas Eastern will store 12 billion cu ft of natural gas per year for Transcontinental, delivering the gas in the winter at a maximum rate of 133,500,000 cu ft per day and receiving redelivery from Transcontinental during the summer months. Transcontinental has agreements covering a 20-year period with seven of its customer companies in the New York, New Jersey, and Philadelphia areas, providing for redelivery to such companies under identical terms as the Texas Eastern-Trancontinental contract.

To perform the service, the wholly owned subsidiary, Texas Eastern Penn-Jersey Transmission Corporation, plans to construct and complete in time for operation in the fall of 1954 a new pipe line system at a total cost estimated at approximately $31,000,000, including 265 miles of 24-in. pipe line extending from the Oakford storage field in western Pennsylvania to the parent company's compressor station No. 26 near Lambertville, New Jersey. That application calls for construction of one 3300-hp compressor station on the 24-in. line near the Oakford storage field and other necessary installations and measuring stations on the system, all of which will be leased to, and operated by, Texas Eastern.

Tennessee Gas Plans

Plans for a 1954 Tennessee Gas Transmission Company construction program to enlarge its natural gas pipe line system were anounced by Charles S. Coates, senior vice president.

The program includes laying approximately 637 miles of pipe line in Louisiana, Mississippi, Tennessee, Ohio, and Pennsylvania; construction of two new compressor stations, and enlarging 5 of its existing 26 stations.

The 637-mile line includes a new 574-mile 30-in. line to begin at the company's compressor station near Kinder, Louisiana, and to join the existing pipe line system at the company's compressor station near Portland, Tennessee.

W. C. McGee, Jr., vice president and general superintendent of operations, said the construction program is expected to begin about June 1.

60-Mile Extension of Line Planned by Cities Service

Extension of its Sour Lake, Texas, to Lake Charles, Louisiana, pipeline system, a distance of 60 miles to the Houston area, has been announced by Cities Service Pipe Line Company. Construction of the oil pipeline is scheduled to start about the first of March, with completion expected early next summer.

Initial capacity of the new 12-in. Sour Lake to Houston extension will be 48,000 bbl daily, with present plans calling for a pump station in the Houston area. The program also provides for construction of six 120,000 bbl floating-roof tanks at the Houston area pump station.

Montana-Dakota to Sell Pipe Lines, Reserves

Montana-Dakota Utilities Company, Minneapolis, Minnesota, has entered into a contract to sell its gas utility properties located in the Great Falls-Havre, Montana, area to The Montana Power Company of Butte, Montana. These properties include transmission and distribution facilities together with gas reserves presently serving northern Montana communities.

Montana-Dakota Utilities also entered into a contract to sell Montana Power Company substantial quantities of natural gas from recently acquired reserves located in the Big Horn Basin.

Montana-Dakota has operated the Great Falls-Havre area properties since 1929 but because of geographical considerations could not integrate these facilities with its extensive gas system.

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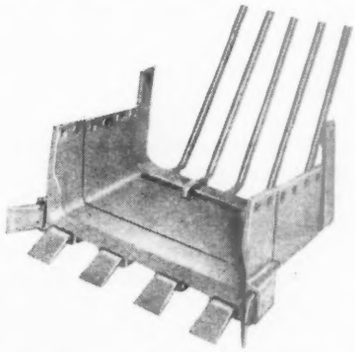

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Merger of Lines Asked By Two Firms of FPC

The Fort Smith Gas Corporation, of Fort Smith, Arkansas, has applied to the Federal Power Commission for authority to acquire the natural gas facilities of Arkansas-Oklahoma Gas Company, also of Fort Smith.

. The application says that the facilities of the two companies actually constitute a single integrated system, serving adjacent market areas in Arkansas and Oklahoma. The companies formerly were members of the same holding company system, and still share the same offices, the application states.

Fort Smith distributes natural gas in the Fort Smith, Van Buren and Alma areas in western Arkansas, and in Pocahontas and Corning in eastern Arkansas. Arkansas-Oklahoma's facilities consist of 61.2 miles of gathering lines; 236.9 miles of transmission lines; 231.6 miles of distribution mains, and 207,000 ft of customers' services. Arkansas-Oklahoma serves markets in Sebastian, Crawford and Franklin Counties, Arkansas, and LeFlore and Sequoyah Counties, Oklahoma.

Harbor System Work Now Underway

Work has begun on the job of simultaneously laying two feeder lines deep under the mile-wide Delaware River for a new defense project petroleum pipe line — the Harbor Products System — that will run across New Jersey to link Philadelphia-area refineries with the New York harbor. The underwater lines will connect two local refineries with the Harbor System's point of origin at Woodbury, New Jersey.

Planned as a dependable, all-weather mover of petroleum products, the Harbor System is expected to go into operation in the spring. It will be a common carrier line providing a direct connection between the nation's second largest refining center and its principal petroleum marketing area.

The refineries to be hooked by the feeder lines to the new carrier are those of the Gulf Corporation at Girard Point and Sinclair Refining Company at Marcus Hook. A third refinery, that of the Texas Company at Eagle Point (Westville) on the Jersey side of the river, will soon be connected to the Harbor System's originating pump station at Woodbury, too.

The Harbor Products System is owned on an undivided interest basis by Gulf Refining Company, Sinclair Pipe Line Company and Texas Pipe Line Company. The 12-in. feeder line from the Gulf refinery and the 8-in. line from Sinclair are owned by the respective companies.

While the feeder lines are being laid under the Delaware, work on the Harbor System itself is moving forward. The new 16-in. carrier will run from Woodbury to Tremley, New Jersey. From there, separate connections will run to Gulf, Sinclair and Texas distribution terminals on the New York harbor. The Harbor System also will connect near its terminus with the new Buckeye Pipe Line which carries products into northeastern Pennsylvania and upper New York.

The Harbor System has been certified as a national defense facility by the Petroleum Administration for Defense. It is being built and will be operated by Sinclair Pipe Line Company, as agent under contract agreement with the owners.

Approval of Merger Asked by Olin Interstate

Olin Interstate Corporation, a wholly-owned subsidiary of Olin Industries, Inc., with main offices in New York City, has applied to the Federal Power Commission for authority to acquire and operate all of the facilities of Interstate Natural Gas Company, of Monroe, Louisiana.

Olin Interstate said that it now owns more than 99 per cent of Interstate Natural's outstanding capital stock, and that it plans to acquire through merger of all the latter company's facilities, properties, contracts and other assets if authorized by the FPC. Upon completion of the merger, the application states, Olin Interstate's name would be changed to Olin Gas Transmission Corporation.

Interstate Natural's facilities are located in Louisiana and Mississippi, and include production properties, a main transmission pipe line system extending from the Monroe field, Louisiana, to Baton Rouge, Louisiana; a number of lateral lines; and facilities for the delivery of natural gas to customers in the Monroe field.

Colorado-Western Plans 454-Mile Gas Pipe Line

Plans for constructing a new 454-mile gas pipe line from southwest Colorado fields to the Denver area have been announced by Colorado-Western Pipe Line Company, headed by John A. McGuire, Dallas. The new line, estimated to cost $33,000,000, would serve some 18 cities in western and central Colorado.

Application has been made to the Public Utilities Commission for authority to build and operate the line, which will be used in intrastate commerce only.

In addition to the 454-mile main line, approximately 254 miles of laterals would be constructed.

TGT Amends Application To Service Equitable

Tennessee Gas Transmission Company, Houston, Texas, has filed an amended application with the Federal Power Commission in connection with its proposal to transport natural gas for the account of Equitable Gas Company, of Pittsburgh, Pennsylvania.

Tennessee originally had proposed to increase the daily design delivery capacity of its pipe line system by about 24,400,000 cu ft of gas per day to enable it to transport the gas for Equitable. Under the plan set forth in the amended application, however, Tennessee would utilize part of the unallocated design day sales capacity that it will have available upon completion of all its authorized construction.

Cost of the facilities proposed in the amended application is estimated at approximately $1,575,000. This would cover the construction of about 50 miles of 10-in. miscellaneous gas supply lateral line in Texas. In original application, Tennessee also proposed to build new compressor units totaling approximately 28,000-hp to be installed in existing stations along the route of its main pipe line system. The project as originally proposed was estimated to cost $9,314,000.

Tennessee Seeks Merger With Northeastern

Tennessee Gas Transmission Company, in an application filed with the FPC, has proposed to acquire and operate its wholly owned subsidiary, Northeastern Gas Transmission Company.

The merger would be accomplished by cancelling Northeastern's $9,000,000 in capital stock, which Tennessee owns, along with cancellation of $8,915,700 in demand notes held by Tennessee. The parent company would assume the bonded indebtedness of Northeastern and transfer the plant, depreciation, and other accounts.

Northeastern operates a 533-mile gas pipe line system in Massachusetts, Connecticut, New Hampshire, and Rhode Island. It also has authorization to do business in Maine and Vermont. The Tennessee system now has more than 6000 miles, including a 2000-mile Texas to New England main line.

Final Section Completing

Crewmen expect to complete the 37.5 mile section of 30-in. pipe line in the final phase of a 73 mile "Biggest Inch" loop that will boost the flow of Texas gas to Southern California.

Work on the section west of Blythe, California, was proceeding ahead of schedule, according to Gas Company Pipe Line Engineer M. J. Binckley.

Mid-Georgia Construction Authorized with Condition

The FPC has affirmed, with modifications, a decision by an FPC Presiding Examiner authorizing Mid-Georgia Natural Gas Company, Atlanta, Georgia, to construct and operate pipe line facilities to supply natural gas from the system of Transcontinental Gas Pipe Line Corporation to several communities in Georgia.

The Commission's order authorizes Mid-Georgia to supply natural gas to Porterdale, Conyers, Millstead, Covington and Oxford, Georgia. The examiner's decision, filed by presiding examiner Ewing G. Simpson, had denied the request for service to Covington and Oxford because of the questionable franchise authorization under which Mid-Georgia proposed to distribute gas to those two communities.

FPC, however, ruled that Mid-Georgia should be allowed to constuct and operate the facilities to serve Covington and Oxford, conditioned upon Mid-Georgia obtaining valid franchise authority pursuant to Georgia Law.

Line From Fosterton Area May Change Direction

A change of direction for the proposed Fosterton medium gravity oil field pipe line has been indicated by inference from a contract signed late in December between the operating companies in the field and a new refiner in the Minneapolis area, Great Northern Oil Company. The contract calls for 10 years' supply of medium gravity crude at 20,000 bbl per day to a refinery to be built by 1955 at Minneapolis-St. Paul. The Great Northern company is owned by Woodley Petroleum Company and Southern Production Company, Inc., both partners with Socony-Vacuum Oil Company, Inc., in the Fosterton four-pool field.

Presumably, the proposed pipe line, originally announced with the intention of cutting into the Interprovincial pipe line at Moose Jaw, is now more likely to run southeast as part of the major operation contained in the Sioux Pipe Line Company plans, including pick-up of United States Williston Basin crude. This would involve construction of at least 100 miles and possibly up to 150 miles of line in Saskatchewan, including gathering systems to pick up crude from the Gull Lake, Rapdan, and Dollard fields which lie within an economic range of any line route out of Fosterton.

No specific plans have been announced as to the route of such a line, but the engineering report of Shell Pipe Line Company, commissioned to prepare a study of the entire proposed Sioux Pipe Line system, will likely contain this when it is delivered in the spring. Construction could start this year.

Short Line Sold

Rock Island Refining Company has purchased a 6-in. line in Oklahoma from Interstate Oil Pipe Line Company. The 17½-mile line, which Rock Island has leased for sometime, is between the Marlow and Tussy stations on Interstate's Oklahoma system.

SECTION OF pipe with oil drip attached and coated is lowered-in on Northern Natural line. Drip is used to trap fluids that accumulate during flow of gas. Photo taken on Northern Natural's 34-mile, 30-in. loop line laid in Nebraska recently.

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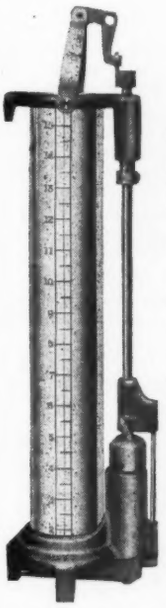
Cuts Gauging Time



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Other exclusive features include: a rotating valve seat to assure proper seating; encased springs to prevent fouling; trip mechanism which accommodates any length trip rod. Sturdily built for longer service. Available in five sizes: 12, 16, 18, 24 and 36 inches. Available through all supply stores.

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Everything the gauger needs from one dependable source.

W. L. Walker Co.

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1009 South Main Tulsa, Oklahoma

WITH THE PIPE LINE CONTRACTORS

Associated Pipe Line Contractors, Inc., Houston, Texas, is working on 175 miles of 10-in. line from Bozeman, Montana, to Clinton, Montana, for Yellowstone Pipe Line Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Bozeman field office.

Collins Construction Company, Victoria, Texas, has contracted from Merritt-Chapman and Scott of India for construction of 84,000 ft of submarine line in the harbor at Bombay, India.

Company also has approximately 2.2 miles of underwater crossing for Socony-Vacuum at Accra, West Africa in joint venture with Taylor-Woodrow, Ltd., West Africa.

Dunn Brothers, 801 Mercantile Building, Dallas, Texas, has the following hauling, stringing and unloading jobs:

335 miles of 30-in. for Gulf Interstate Gas Company between Kinkade, Tennessee, and Kenova, West Virginia. Prime contractor is H. C. Price Company.

Approximately 300 miles of 4 to 6-in. pipe for El Paso for a gathering system in the Farmington, New Mexico, area. El Paso doing own construction.

56 miles of 8-in. for Magnolia Pipe Line Company between Seminole, Texas, and Bronco, New Mexico. Prime contractor is H. B. Zachry.

140 miles of 30-in. for Tennessee Gas Transmission Company between Savannah, Tennessee, and the Tennessee-Kentucky state line.

62 miles of 30-in. for Tennessee Gas Transmission Company between Lisbon and Cambridge, Ohio.

El Paso Natural Gas Company, El Paso, Texas, has crews working on 300 miles of 4 to 16-in. gathering system lines near Bloomfield, New Mexico, at the Blanco field. Superintendent is Joe Self and B. R. Jones, office manager.

El Paso crews are also starting on 200 miles of 30-in. line from Winslow, Arizona, to Gallup, New Mexico. J. E. Lowry is job superintendent and J. S. Smith, office manager.

Williams Brothers Company, 324 National Bank of Tulsa Building, Tulsa, Oklahoma, has contract for 615 miles of 8-in. products line in Alaska for the U. S. Corps of Engineers in a joint venture with McLaughline, Inc., and Marwell Construction Company.

Company also has 75 miles of 12-in. line for Oklahoma-Mississippi River Products Pipe Line, Inc., between White River, Arkansas, and Memphis, Tennessee. Jim Childers is superintendent and George Gossett, office manager, at the Patterson, Arkansas, field office.

Company has contract for 50 miles of line for North Carolina Public Service Company near Hendersonville, North Carolina. Work was begun in early December.

Williams Pressure Service Company, 422 Commercial National Bank Building, Shreveport, Louisiana, has two fill units working on the Lakehead Pipe Line as part of hydrostatic testing operation. Willard Wilkerson is superintendent at the St. Ignace, Michigan, field office.

Engineering-Construction Company, 402 North Cheyenne, Tulsa 6, Oklahoma, is working on 94 miles of 16-in. line for East Tennessee Natural Gas Company between Knoxville and Kingsport, Tennessee. Also being laid on the same job are 56 miles of 4 through 12-in. line in laterals from the main line. Jim Williams is superintendent and J. W. Tyner, office manager, at the Morristown, Tennessee, office.

Company is also constructing approximately 65 miles of 4 through 26-in. line near Elkhart, Kansas, for Colorado Interstate Gas Company. Earl Hackleman is spreadman and H. B. Hoge office manager on the Elkhart job.

Engineers Limited Pipeline Company, 225 Bush Street, San Francisco, California, is working on 90 miles of 34-in. for Pacific Gas and Electric in California.

Company also has 81 miles of 10-in. line for Yellowstone Pipe Line Company between Murray, Idaho, and Spokane, Washington. C. P. Hamilton is superintendent and Virgil Darby, office manager.

Foster Wheeler Corporation, 165 Broadway, New York 6, New York, has contract with North Atlantic Treaty Organization for management of 1920 miles of product line to be laid in Western Europe.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, is constructing 250 miles of 30-in. line for El Paso Natural Gas Company between Corona and Gallup, New Mexico. A. A. Carrigan is superintendent and Bill Cohoon office manager for spread one; M. L. Boyd is superintendent and Charles Siewert office manager on spread two.

Company has 58 miles of 16 and 20-in. line for Cities Service Gas Company near Purcell, Oklahoma. Vance Albers is superintendent and C. E. Helweg office manager.

H. C. Price Co., Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 355 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company starting at a point near Gordonsburg, Tennessee, and extending northeasterly to a point near Catlettsburg, Kentucky. Approximately 75 miles remaining to be completed.

Houston Contracting Company, Ltd., 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. Three spreads on this work as follows:

From Mississippi River going north, E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager; present headquarters, Water Valley, Mississippi. Approximately 165 miles completed.

From Ouachita River going south, R. L. Silar, superintendent; L. F. Redfearn, field office manager; headquarters, Jena, Louisiana. Approximately 117 miles completed.

From Ouachita River going north, M. L. Thompson, superintendent; J. B. Stoddard, field office manager; headquarters will be in Winnsboro, Louisiana.

Operations on all three spreads have been suspended for the winter months.

Lone Star Constructors, 1014 Mercantile Bank Building, Dallas, Texas, is working on 45 miles of 14 and 16-in. line for Arkansas-Louisiana Natural Gas Company, between Waskom and Longview, Texas. H. A. Wylie is superintendent and H. O. Hall, Jr., office manager.

Merritt-Chapman and Scott, 260 Madison Avenue, New York 16, New York, has contract for pipe line system in India to link two refineries under construction at Bombay, India. Work has just begun, machinery being set up and coating of pipe underway.

C. E. Wilson Construction Company, 1401 Fairfax Trafficway, Kansas City 15, Kansas, has completed a products terminal at Geneva, Nebraska, for Kaneb Pipe Line Company. Company also has undetermined amount of ¾ through 4-in. line in Cedar Rapids, Iowa, for Iowa-Illinois Gas and Electric Company.

River Construction Corporation, 6100 Bowie Boulevard, Fort Worth, Texas, has 73 miles of 30-in. line in Riverside County, California, for Southern California Gas Company.

Company has contract for 303 miles of 12-in. and 97 miles of 10-in. for the Oklahoma-Mississippi River Products Pipe Line, Inc.

Company also has 25 miles of 30-in. for United Gas between Pasadena and Missouri City, Texas.

Western Pipe Line Constructors, Box 798, Austin, Texas, is working on 167 miles of 30-in. line for El Paso Natural Gas Company between Kingman and Flagstaff, Arizona. Benny Williams is superintendent and P. O. Rutledge office manager at the Williams, Arizona, field office.

Oklahoma Pipe Line Constructors, 6612 Harry Hines Boulevard, Dallas, Texas, is laying approximately 150 miles of 30-in. for El Paso Natural Gas Company between Denver City, Texas, to a point near Roswell, New Mexico. Two spreads are working on the job. Louis Visentine is superintendent of spread one. E. R. Law is superintendent of spread two and Gene Gohring is assistant superintendent. R. F. Mueller is office manager and Geno Gallina purchasing agent.

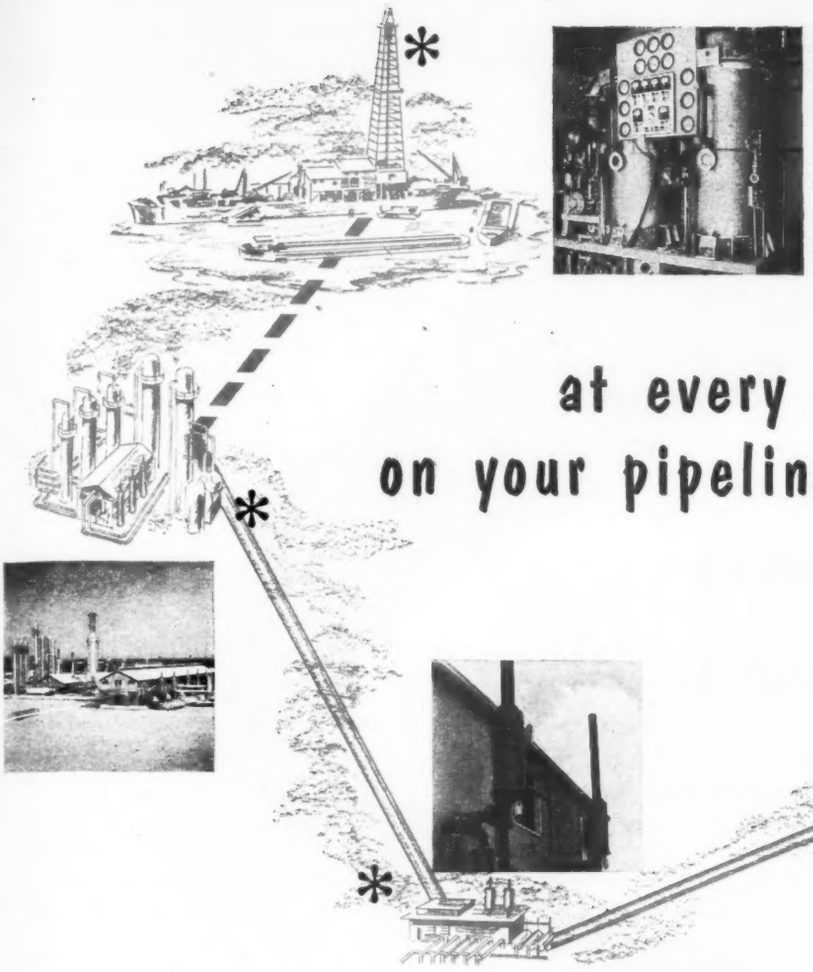
Parkhill Truck Company, P. O. Box 1856, Tulsa, Oklahoma, reports the following work:

Hauling 30-in. pipe for Gulf Interstate Gas Company from Houston and Orange, Texas, to storage points in eastern Louisiana and Mississippi.

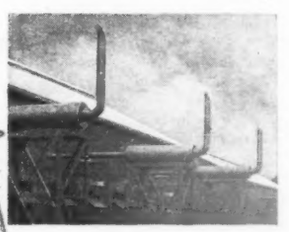
Hauling, storing where necessary, and stringing approximately 303 miles of 12-in. pipe from White River to Allen, Oklahoma, for Sunray Oil Corporation. Contractor, River Construction Corporation. Also approximately 97 miles of 10-in. pipe from Allen, Oklahoma, to Duncan, Oklahoma.

Unload, haul and string approximately 13 miles of 16-in. and 29 miles of 12-in. pipe for Gulf Interstate gathering system in Louisiana. Contractor, Associated Pipe Line Contractors, Inc.

Hauling and stringing 25 miles of 30-in. pipe for United Gas Company between Pasadena and Missouri City, Texas.



at every point * on your pipeline to PROFIT



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Type	Diameter	Length	Wall Thickness	Shipping Point
Continuous Weld—Threaded and Coupled	½" to 4" nominal I.D.	Uniform 21'	Standard	Fontana, Calif.
Continuous Weld—Plain End	2⅜" to 4½" O.D.	Up to 40'	Standard	Fontana, Calif.
Electric Resistance and Fusion Weld—Plain End	14" to 18" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser
Electric Resistance Weld—Plain End	5⅝" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
Electric Fusion Weld—Expanded—Plain End	20" to 30" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser

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Big Loop Program Scheduled on Interprovincial's Line

INTERPROVINCIAL Pipe Line Company will complete the looping of its entire central division between Regina, Saskatchewan, and Gretna, Manitoba, with 24-in. pipe, next summer, and will lay a substantial mileage of 26-in. loop on the other two divisions. President T. S. Johnston has announced location of the 24-in. loop sections, a total of 98 miles completing four gaps left in this 334.3-mile division after the 1952 and 1953 loop construction jobs. The 26-in. loop will consist of about 200 miles in the eastern division, operated by Lakehead Pipe Line Company in Minnestota between Gretna, Manitoba, and Superior, Wisconsin, and about 300 miles in the western division between Edmonton and Regina.

Eighteen miles of 24-in. loop will be laid east from Regina to a point near Davin where it meets the western end of the loop section laid in 1953. Ten miles will be laid between Peebles and Kipling, between the eastern end of a 1952 loop section and the western end of a section laid in the 1953 program. These sections are both in Saskatchewan. Straddling the Saskatchewan-Manitoba border, the longest 1954 section will be approximately 52 miles, running from Kelso scraper trap in Saskatchewan and a point between Scarth and Maon in Manitoba at the western end of a 1953 loop section. The remaining section of 18 miles will link Gretna station with the point near Winkler, Manitoba, where the 1953 construction program started. The central division, with this loop in the ground by the end of next summer, will have a complete 16-in. and a complete 24-in. line for its entire distance.

Exact location of the western division loop has not been determined, and this has held up bidding. The reason is the desire of the company to determine approximately how much oil is likely to be offered for transportation from the recently discovered Smiley field in western Saskatchewan, 25 miles from Kerrobert station. There is some indication that Imperial Oil Limited may take as much as 12,000 bbl per day of this production for its Regina refinery by the end of next summer, in which case the easterly 200 miles of this 438-mile division would have to carry a larger load than the westerly portion and would probably have the larger proportion of the 300 miles of loop. This division consists of 20-in. pipe in the original line and has not yet been looped at all.

Location of the 26-in. loop in the 324-mile Lakehead division has not been decided.

New Stations Planned

Five new stations will be constructed in Canada, on the sites of existing stations, and three in the United States, in the 1954 construction season. One station will be built on the 30-in. line between Superior and Sarnia, which was completed at the end of November and made first delivery of crude to Sarnia early in January. The Canadian station construction will consist virtually of addition of one unit to each existing station, at the points where the additions are to be installed. Locations have not been announced.

Total throughout capacity of the system will be 205,000 bbl per day out of Edmonton when the combined loop and station program is completed. *

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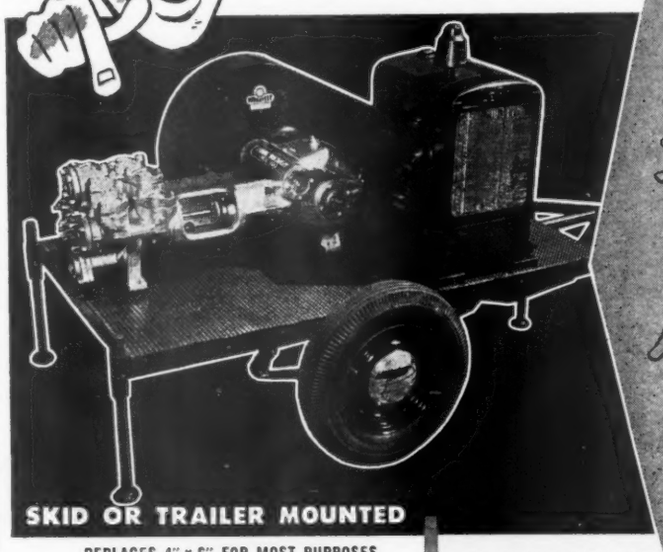

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PORTABLE
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REPLACES 4" x 6" FOR MOST PURPOSES

Piston	Stroke	BPH	R&I	HP	Wt. Lbs.	Plunger Load
2"	5	35	900	15	700	2500±
2½"	5	56	520	15	700	
3"	5	83	350	15	700	
3½"	5	115	255	15	700	

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- POT TYPE FLUID END
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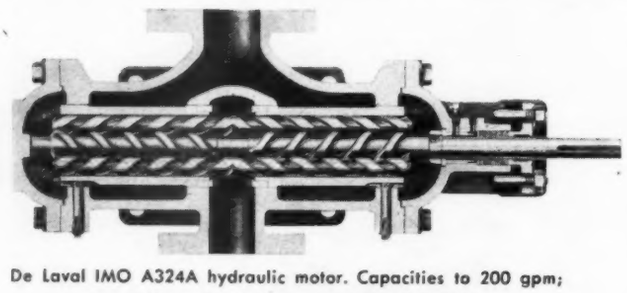
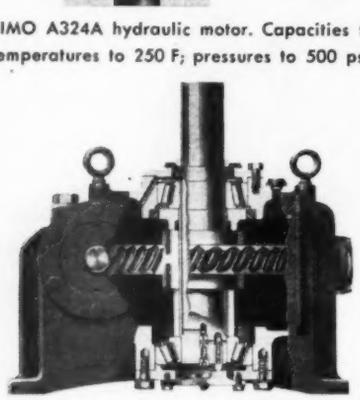
HYDRAULIC FAN DRIVE

De Laval IMO hydraulic motor
teamed with De Laval Worm Gear at Carter Oil Company



De Laval IMO A324A hydraulic motor. Capacities to 200 gpm; temperatures to 250 F; pressures to 500 psig.



De Laval Type WVC Worm Gear; 5 to 75 hp; ratios 3⅝:1 to 11⅔:1; center distance 4.00" to 13.50".

De Laval IMO hydraulic motors and pumps have operated twenty-four hours a day for over two years on the Happy Cooling Tower at the Carter Oil Company, Elmore City, Oklahoma Compressor Station.

Fans are driven through De Laval WVC Worm Gear Reducers. There is absolutely no vibration or noise. The equipment has yet to require maintenance of any consequence. Indications point to a long, trouble-free life expectancy.

Here's why De Laval IMO Hydraulic Drives insure trouble-free service. The IMO hydraulic motor has no bearings, no reciprocating parts, no vanes, no timing gears, no intricate sub-assemblies. The drive is in complete hydraulic balance. The simple basic IMO design has only three moving parts.

Call in your De Laval representative. He can solve your problem quickly in the application of De Laval completely standard hydraulic motors, pumps and worm gear reducers. Or, ask your heat exchanger supplier to specify De Laval drives.

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Pipe Line Personals

Claude L. Draper, member of the Federal Power Commission since 1930, has been unanimously re-elected as vice chairman of the group for the calendar year 1954. Draper, a Republican and a native of Cheyenne, Wyoming, is the dean of the commission in point of service and has served under four presidents.

Kirkman M. Stubblefield and **W. N. "Bill" Ward** have been promoted to mechanical foremen in the Southern division of Interstate Oil Pipe Line Company. Ward has been with Interstate for 18 years and Stubblefield 16 years.

W. E. Mueller has been elected president of Colorado Interstate Gas Company, succeeding **Robert W. Hendee,** who has resigned. Hendee is a member of the company's board of directors and will continue in that capacity and as a consultant to company management. Mueller joined the company in 1952 as executive vice president. He was formerly senior vice president with Tennessee Gas Transmission Company of Houston.

John W. Hopkins, superintendent of compressor stations since 1944, has been named general superintendent of Colorado Interstate. **L. M. Stone,** assistant controller the past two years, has been promoted to controller.

Albert S. Munneke, superintendent of Service Pipe Line Company's Salt Creek district in Wyoming, has been transferred to Williston, North Dakota, as superintendent of a new North Dakota district. **R. R. Strand,** Casper, is the Wyoming division manager of which the North Dakota district is a part.

Munneke will be replaced by **John H. Keyes, Jr.,** of Casper, formerly division chief engineer for the company in Wyoming. **W. L. "Stretch" Kennedy, Jr.,** a senior engineer in the Tulsa headquarters, is taking a leave from this post, to temporarily replace Keyes at Casper.

Charles Ashmun has been appointed to the newly created position of Supervisor of Oil Movements for The Buckeye Pipe Line Company, with headquarters in the general offices at Lima, Ohio.

Ashmun graduated from Kent School, Kent, Connecticut in 1936. He joined Buckeye in 1939 learning the pipe line business from the bottom up. His first job was as a laborer in the field repair gang and later after working as clerk in various departments of the company's New York office, he was appointed in 1948 assistant to the oil traffic manager. In 1950, he received the appointment as assistant to the vice president and in this capacity was in charge of industrial relations.

Wallace W. Mitchell, Coalinga, California, has been appointed acting superintendent of Tide Water Associated Oil's San Joaquin Valley pipe line system, replacing **Grove E. Herrmann,** who has retired.

Mitchell will make his headquarters at Coalinga, where the head office of the 250 mile crude oil carrying pipe line system is located. He will supervise the company's Valley gathering and trunk line system and its Monterey, California, marine terminal.

The pipe line runs up the western side of the San Joaquin Valley in Central California from Fellows to the company's 1500 acre Avon refinery at Associated, California, on San Francisco Bay. Mitchell first worked for Tide Water Associated in 1928 while still in college as a pipe line roustabout in the Coalinga area.

George A. Morgan, superintendent, market research department, Peoples Gas Light and Coke Company, Chicago, has been appointed chairman of the rate committee of the American Gas Association. The AGA Rate Committee makes studies of various costs involved in supplying gas to different classes of customers and recommends forms of rates designed to meet such costs equitably and at the same time to secure adequate and just revenue.

B. H. Harper, secretary, Northern Natural Gas Company, Omaha, Nebraska, has been appointed chairman of the corporate secretaries committee of the American Gas Association for 1954, it was announced recently. This committee was formed during the AGA annual convention in October 1950, at the suggestion of Harper, to study and develop methods for meeting the problems of corporate secretaries. **Dale Parker,** secretary, The Columbia Gas System, Inc., New York, New York, served as the initial chairman of the committee.

J. G. Norton

A. T. Glover

J. E. McGeath

R. L. Taylor

John G. Norton, chief mechanical engineer for Magnolia Pipe Line Company, has been elected a member of the company's board of directors. He succeeds **A. T. Glover,** general superintendent, who has retired after 41 years' service.

Joe E. McGeath, who has been assistant general superintendent, has been promoted to general superintendent. **R. L. Taylor,** formerly administrative assistant, has been promoted to assistant to the manager. **J. J. Harris,** mechanical engineer, has been transferred to the dispatching department as engineer.

Prof. Robert S. Green, chairman of the department of welding engineering at the Ohio State University, has been named executive director of the university's Engineering Experiment Station. He succeeds Prof. Jacob R. Shank, assistant director since 1938, who asked to be relieved as the administrative head of the station to devote his full time to his professorship in the department of civil engineering. The change becomes effective April 1, 1954.

C. H. Gompf

O. F. Moore

O. F. Moore, vice president of Ohio Oil Company, who has been manager of pipe lines, will become manager of the new supply and transportation department that will embrace the company's varied operations in transportation and supply of crude oil and refined products. **J. R. Donnell,** now treasurer of the company, will become assistant manager of the new department.

Grouped in the new department for greater efficiency and coordination will be the present pipe line, crude oil purchase and sales, refined products supply and transportation, traffic, and aviation departments.

C. H. Gompf, now assistant manager of pipe lines, will succeed Moore as manager of pipe lines. **J. H. Rice,** division superintendent of pipe lines at Casper, Wyoming, will move to the general office at Findlay, Ohio, as assistant manager of pipe lines. **Clare McElhinny,** assistant division superintendent at Casper, will advance to division superintendent, succeeding Rice.

L. T. Weger will become assistant manager of the crude oil purchase and sales department, headed by **D. R. Williams.** Weger moves to the general office from Casper, where he is currently in charge of crude oil sales in the Rocky Mountain area.

M. D. King, former assistant to the manager of refining and marketing, will join the staff of the refined products supply and transportation department as an assistant manager. **L. B. McCammon** continues as manager and **L. R. Snyder** as an assistant manager.

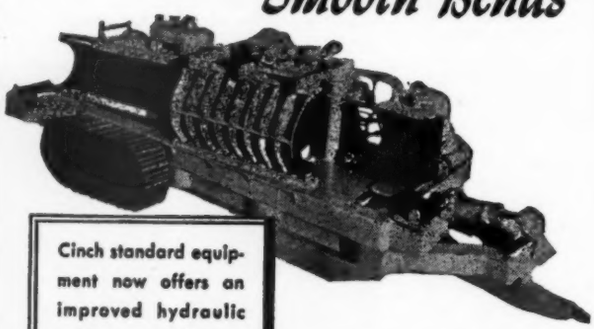
Roy Lunday, former superintendent of District 1 has been named superintendent of District "C" for Panhandle Eastern Pipe Line Company. **E. B. Newhouse,** former assistant superintendent at District "D" has been promoted to District "B" superintendent. **W. R. Newton** has been appointed to Newhouse's former post.

W. H. Adams, safety consultant at AGA since 1951, has retired. A veteran of more than fifty years' service in the gas industry, Adams joined the AGA after serving as safety director of Manufacturers Light and Heat Company.

He directed the AGA's intensified accident prevention campaign, disseminating information to the industry. He rendered valuable service to gas utility and pipe line companies in the industry.

CINCH

Affords Faster, Smooth Bends



Cinch standard equipment now offers an improved hydraulic system and new wedge-type pin-up slide for greater durability and speed. If desired, even faster, easier maneuvering can be obtained with Athey tracks and hydraulic lift tongue.

Contractors swear by Cinch "Smooth Bend" Pipe Benders for dependability and uninterrupted service. Cinch Pipeline Equipment provides the most up-to-date equipment and expert maintenance.

PIPE BENDERS — LINE-UP CLAMPS

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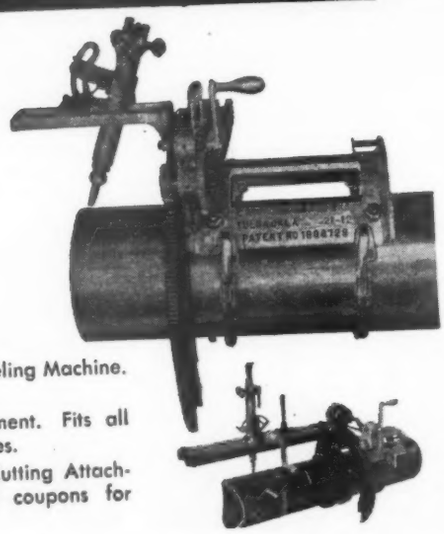

Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

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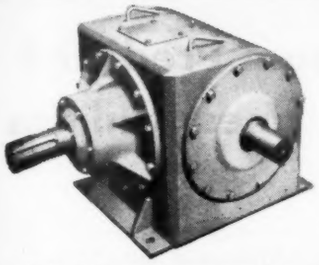
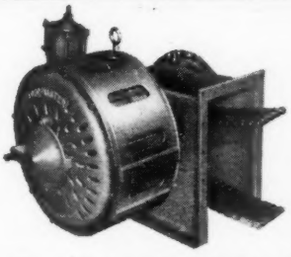
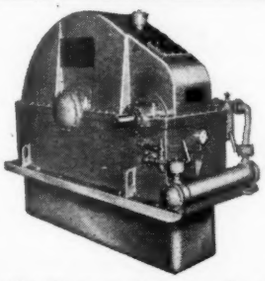


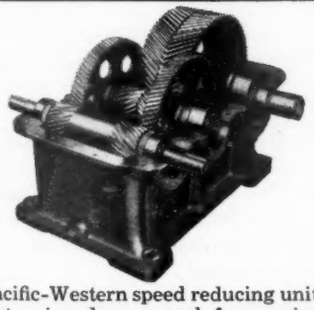
This right-angle gear box is designed for transmitting power to operate a rotary table.



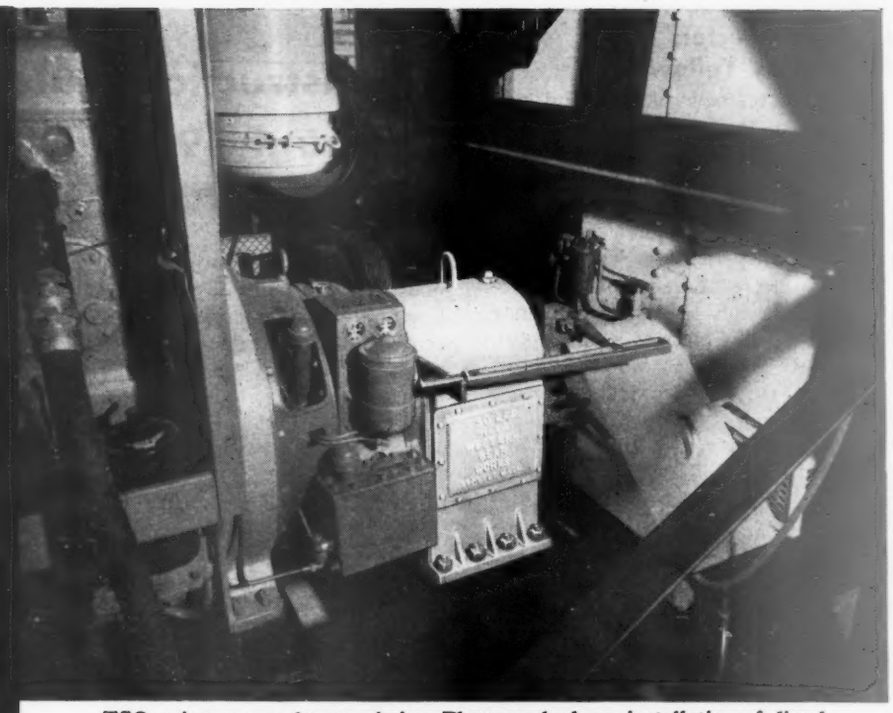
The Torq-Master unit is designed for application to Torque-Converters and can be adapted to Pacific-Western Converters and other leading makes.



Pacific-Western high speed units for stepping-up speed from prime mover to pump.



Pacific-Western speed reducing units for stepping-down speed from prime mover to pump. (Case cover removed.)



TSO unit two speed transmission. Photograph shows installation of diesel engine used to drive rotary table drive.

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XUM

PIPE LINE PERSONALS

Officers, Directors Named by Yellowstone

Election of new officers and new members of the board of directors of Yellowstone Pipe Line Company, 537-mile pipe line currently under construction from Billings, Montana, to Spokane, Washington, has been announced.

Newly elected officers of the company are Joseph L. Seger, Interstate Oil Pipe Line Company, Shreveport, Louisiana, president; W. L. Kygar, Continental Pipe Line Company, Ponca City, Oklahoma, vice president and general manager; John D. Morrow, Continental Pipe Line Company, secretary; R. L. Bosworth, Continental Oil Company, Houston, Texas, treasurer; and P. H. Hunter, Interstate Oil Pipe Line Company, assistant secretary-treasurer.

Continental Pipe Line Company is a wholly owned subsidiary of Continental Oil Company, and Interstate Oil Pipe Line Company is an affiliate of The Carter Oil Company.

Elected to the Yellowstone board of directors were Seger; Kygar; Thomas Brownfield, Carter Oil Company, Tulsa, Oklahoma; J. W. Liddell, Continental Oil Company, Denver, Colorado; T. A. van Griethuysen, Continental Oil Company, Houston; E. L. Hiatt, Union Oil Company of California, Los Angeles; and W. Turner Clack, The H. Earl Clack Company, Spokane, Washington.

Initially the new line will have two pumping stations, one located at Billings and the other at Helena, Montana, with a daily capacity of 30,000 bbl. The capacity can be increased to 50,000 bbl per day by installing additional pumping facilities.

The line, now being constructed under the supervision of Continental Pipe Line Company, is expected to be completed in August, 1954. A six-mile section of 8-in. pipe line has been completed to connect to the Salt Lake Pipe Line Company system at Spokane. At present, 151 miles of line have been completed.

Delivery facilities along the route of the line are being constructed at Bozeman, Helena, and Missoula, Montana, and Spokane, Washington, the western terminus of the Yellowstone system. Gasolines, fuel oil, and other refined products for shipment through Yellowstone will be largely supplied by the Continental Oil Company refinery and the Carter Oil Company refinery, both located at Billings, Montana.

▸ **A. N. Horne** has been elected a director and vice president and general manager of Texas-Empire Pipe Line Company. At the same time **C. H. Albitz,** Houston, was elected a director.

Construction, Sales Boom Predicted Through 1956 for Pipe Lines, Utilities

SALES of gas by utilities and pipe lines in 1956 will total about 71.6 billion therms, an increase of 33.1 per cent over actual sales of 53.8 billion therms in 1952, and 25.8 per cent higher than estimated sales of 57 billion therms in 1953. This estimate was published recently by American Gas Association in a report: "Gas Requirements and Supplies of the Gas Utility and Pipeline Industry."

The report covers industry estimates on an annual basis through 1956 as well as forecasts of peak day requirements and supply through the 1956-1957 heating season.

Future Demand Higher

Anticipated 1956 space heating demand will exceed 1952 requirements by approximately 55 per cent. This is the largest relative gain foreseen in any class of service. Residential space heating customers are expected to number 16.1 million in 1956, an increase of 38 per cent over the total served by the industry at the end of 1952.

The demand for gas for space heating is increasing more rapidly than the rate of customer growth. Acceptance of gas for space heating is growing rapidly in Northern areas under the impetus of pipe line expansion programs. Generally speaking southern areas now have a higher degree of space heating saturation. Residential space heating will account for 23 per cent of total annual gas requirements in 1956, compared to less than 20 per cent in 1952.

Sales to interruptible industrial customers are expected to increase only slightly as the gas industry utilizes underground storage facilities more extensively in meeting peak load requirements imposed by househeating demands. Total withdrawals of natural gas from underground storage in 1956 will approach 4.4 billion therms, representing a gain of 110 per cent over total withdrawals in 1952.

Storage Increase Significant

The increased use of underground storage in aiding pipelines to operate at high annual load factors perhaps is one of the most significant developments shown in the survey. More than one-third of the total increase in peak day availability of natural gas from the 1952-1953 season to the 1956-1957 heating season is attributable to increased withdrawals from underground storage.

Millions of therms.

	Annual		Peak Day	
	1956	1953	1956-57	1953-54
Residential.....	24,600	17,800	234	182
Commercial.....	6,300	5,100	50	40
Industrial and other.	40,700	34,000	90	77
Total.....	71,600	56,900	374	299

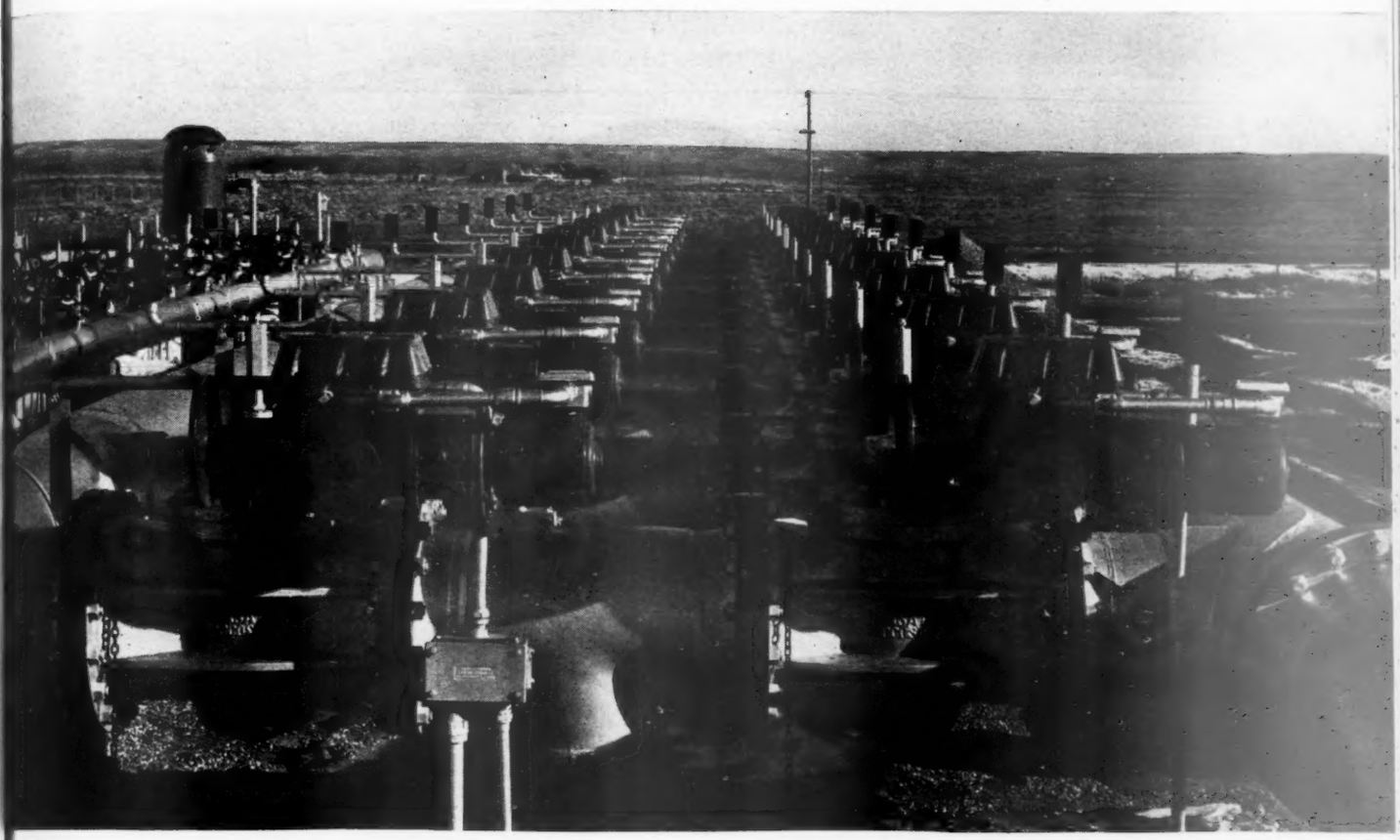
Peak day requirements for residential space heating are expected to advance about 49.2 per cent during the the four years to total more than 205 million therms. Total peak day firm requirements for all sales and company use in the 1956-1957 heating season will be about 403,700,000 therms while total supply as now estimated will be about 402,000,000 therms. Concrete plans will be made, without doubt, to provide adequate supplies to meet the slight deficiency which appears only in the last year of the series.

The industry will require 7,300,000 tons of steel pipe for its expansion program from 1953 through 1956. The major portion represents steel pipe of 16-in. and larger diameter, which will require 4.9 million tons or 67 per cent of the total. Pipe of this size is used primarily by transmission companies to construct major lines.

New construction costs are expected to aggregate $4 billion in the four-year period with an estimated $1.9 billion being expended for transmission facilities. About $1.4 billion will be spent on new distribution facilities with the remainder going for production, underground storage and general plant expansion.

The report on which these statistics are based is essentially a continuation of a previous survey conducted by the Gas Planning Division of the Petroleum Administration for Defense. In recognition of the importance of such data, the A.G.A. will continue to compile statistics relating to future gas supplies and operations. Absence of such statistics has hampered the gas industry and has hindered the steel industry attempts to develop long-term plans for pipe-fabrication expansion. Such plans are necessary to ensure adequate supplies of steel pipe and other materials to the gas industry.

A brief summary comparing 1956 requirements with estimated 1953 sales is shown in the table. * * *



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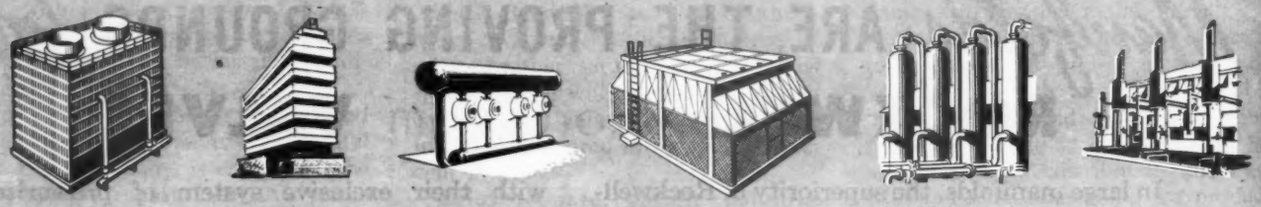

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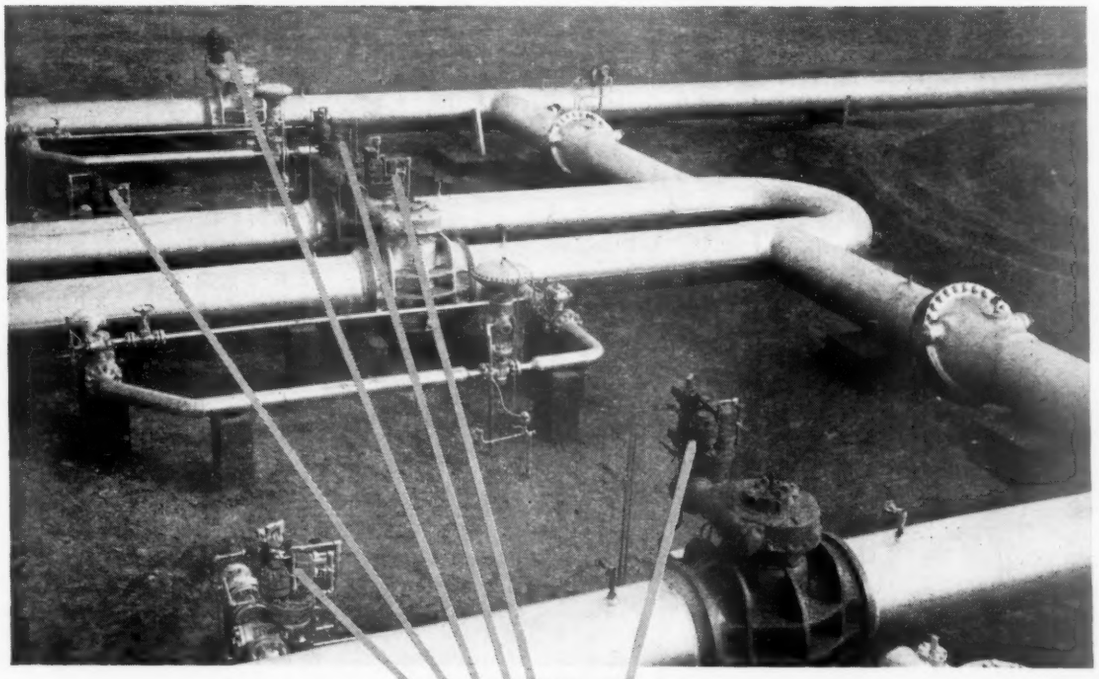

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VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH 2-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	8.1	3.1	.0	1.5	1.2	1.0	0.9	0.8	0.7
100		16.3	6.3	4.0	3.0	2.4	2.0	1.8	1.6	1.4
150		24.4	9.4	6.0	4.4	3.6	3.0	2.6	2.3	2.1
200		32.6	12.6	8.0	5.9	4.8	4.0	3.5	3.1	2.8
250		40.7	15.7	10.0	7.4	6.0	5.0	4.4	3.9	3.5
300		48.9	18.9	12.0	8.9	7.2	6.0	5.3	4.7	4.2
350		57.0	22.0	14.0	10.4	8.4	7.0	6.1	5.5	5.0
400		65.2	25.2	16.0	11.9	9.5	8.0	7.0	6.2	5.7
50	400	10.8	4.1	2.6	1.9	1.5	1.3	1.1	1.0	0.9
100		21.6	8.3	5.2	3.9	3.1	2.6	2.2	2.0	1.8
150		32.4	12.4	7.8	5.8	4.6	3.9	3.4	3.0	2.7
200		43.2	16.6	10.4	7.7	6.2	5.2	4.5	4.0	3.6
250		54.1	20.7	13.1	9.6	7.7	6.5	5.6	5.0	4.5
300		64.9	24.9	15.7	11.6	9.2	7.8	6.7	6.0	5.4
350		75.7	29.0	18.3	13.5	10.8	9.0	7.8	6.9	6.3
400		86.5	33.2	20.9	15.4	12.3	10.3	9.0	7.9	7.2
50	500	13.5	5.1	3.2	2.4	1.9	1.6	1.4	1.2	1.1
100		27.0	10.3	6.5	4.7	3.8	3.2	2.7	2.4	2.2
150		40.4	15.4	9.7	7.1	5.7	4.7	4.1	3.6	3.2
200		53.9	20.6	12.9	9.5	7.6	6.3	5.4	4.8	4.3
250		67.4	25.7	16.1	11.9	9.4	7.9	6.8	6.0	5.4
300		80.9	30.9	19.4	14.2	11.3	9.5	8.2	7.2	6.5
350		94.4	36.0	22.6	16.6	13.2	11.0	9.5	8.4	7.6
400		108.	41.2	25.8	19.0	15.1	12.6	10.9	9.6	8.6
50	600	16.2	6.1	3.8	2.8	2.2	1.9	1.6	1.4	1.3
100		32.3	12.3	7.7	5.6	4.5	3.7	3.2	2.8	2.5
150		48.5	18.4	11.5	8.4	6.7	5.6	4.8	4.2	3.8
200		64.6	24.6	15.4	11.3	8.9	7.5	6.4	5.7	5.1
250		80.8	30.7	19.2	14.1	11.2	9.3	8.0	7.1	6.3
300		96.9	36.9	23.1	16.9	13.4	11.2	9.6	8.5	7.6
350		113.	43.0	26.9	19.7	15.7	13.0	11.2	9.9	8.9
400		129.	49.2	30.7	22.5	17.9	14.9	12.8	11.3	10.1
50	700	18.8	7.1	4.5	3.3	2.6	2.1	1.8	1.6	1.5
100		37.6	14.3	8.9	6.5	5.2	4.3	3.7	3.2	2.9
150		56.4	21.4	13.4	9.8	7.7	6.4	5.5	4.9	4.4
200		75.2	28.6	17.8	13.0	10.3	8.6	7.4	6.5	5.8
250		94.1	35.7	22.3	16.3	12.9	10.7	9.2	8.1	7.3
300		113.	42.9	26.7	19.6	15.5	12.9	11.1	9.7	8.7
350		132.	50.0	31.2	22.8	18.1	15.0	12.9	11.4	10.2
400		150.	57.2	35.7	26.1	20.7	17.2	14.8	13.0	11.6
50	800	21.5	8.1	5.1	3.7	2.9	2.4	2.1	1.8	1.6
100		43.0	16.3	10.1	7.4	5.9	4.9	4.2	3.7	3.3
150		64.4	24.4	15.2	11.1	8.8	7.3	6.3	5.5	4.9
200		85.9	32.6	20.3	14.8	11.7	9.7	8.4	7.3	6.6
250		107.	40.7	25.4	18.5	14.7	12.2	10.4	9.2	8.2
300		129.	48.9	30.4	22.2	17.6	14.6	12.5	11.0	9.8
350		150.	57.0	35.5	25.9	20.5	17.0	14.6	12.8	11.5
400		172.	65.2	40.6	29.6	23.4	19.5	16.7	14.7	13.1
50	900	24.1	9.1	5.7	4.1	3.3	2.7	2.3	2.0	1.8
100		48.3	18.3	11.4	8.3	6.6	5.4	4.7	4.1	3.6
150		72.4	27.4	17.1	12.4	9.8	8.2	7.0	6.1	5.5
200		96.6	36.6	22.7	16.6	13.1	10.9	9.3	8.2	7.3
250		121.	45.7	28.4	20.7	16.4	13.6	11.7	10.2	9.1
300		145.	54.9	34.1	24.9	19.7	16.3	14.0	12.3	10.9
350		169.	64.0	39.8	29.0	23.0	19.0	16.3	14.3	12.8
400		193.	73.2	45.5	33.2	26.2	1.8	18.6	16.4	14.6

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into the velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the no. of atmospheres.

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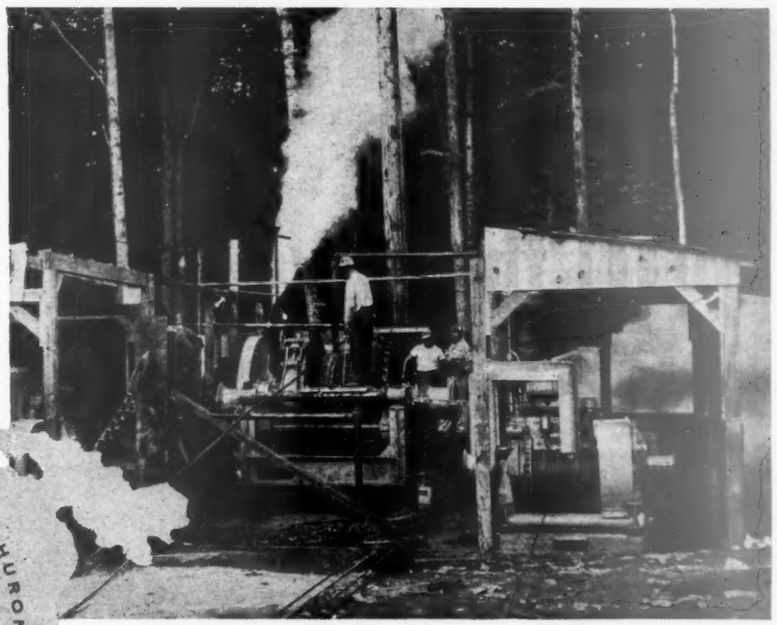
To obtain more information on products advertised see page E-69

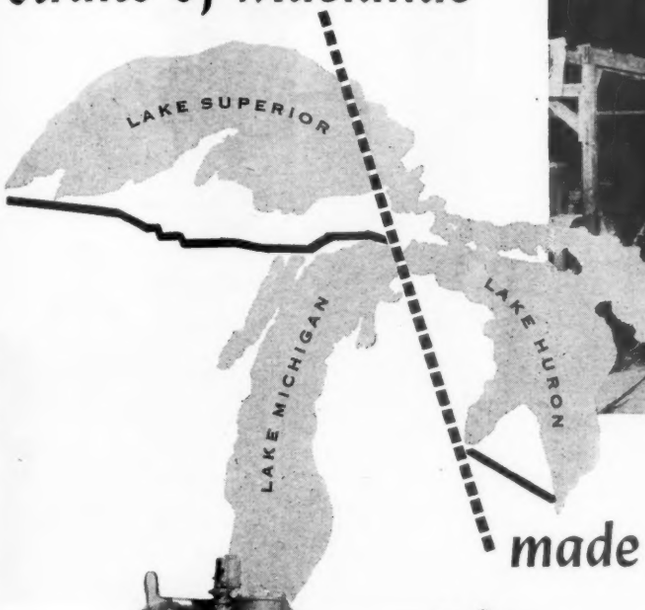
VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH 4-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	2.1	0.8	0.5	0.4	0.3	0.3	0.2	0.2	0.2
100		4.1	1.6	1.0	0.8	0.6	0.5	0.4	0.4	0.4
150		6.2	2.4	1.5	1.1	0.9	0.8	0.7	0.6	0.5
200		8.3	3.2	2.0	1.5	1.2	1.0	0.9	0.8	0.7
250		10.4	4.0	2.5	1.9	1.5	1.3	1.1	1.0	0.9
300		12.4	4.8	3.0	2.3	1.8	1.5	1.3	1.2	1.1
350		14.5	5.6	3.5	2.6	2.1	1.8	1.6	1.4	1.3
400		16.6	6.4	4.1	3.0	2.4	2.0	1.8	1.6	1.4
50	400	2.7	1.1	0.7	0.5	0.4	0.3	0.3	0.3	0.2
100		5.5	2.1	1.3	1.0	0.8	0.7	0.6	0.5	0.5
150		8.2	3.2	2.0	1.5	1.2	1.0	0.9	0.8	0.7
200		11.0	4.2	2.7	2.0	1.6	1.3	1.1	1.0	0.9
250		13.7	5.3	3.3	2.5	1.9	1.6	1.4	1.3	1.1
300		16.5	6.3	4.0	2.9	2.3	2.0	1.7	1.5	1.4
350		19.2	7.4	4.6	3.4	2.7	2.3	2.0	1.8	1.6
400		22.0	8.4	5.3	3.9	3.1	2.6	2.3	2.0	1.8
50	500	3.4	1.3	0.8	0.6	0.5	0.4	0.3	0.3	0.3
100		6.8	2.6	1.6	1.2	1.0	0.8	0.7	0.6	0.5
150		10.3	3.9	2.5	1.8	1.4	1.2	1.0	0.9	0.8
200		13.7	5.2	3.3	2.4	1.9	1.6	1.4	1.2	1.1
250		17.1	6.5	4.1	3.0	2.4	2.0	1.7	1.5	1.4
300		20.5	7.8	4.9	3.6	2.9	2.4	2.1	1.8	1.6
350		24.0	9.2	5.7	4.2	3.4	2.8	2.4	2.1	1.9
400		27.4	10.5	6.6	4.8	3.8	3.2	2.8	2.4	2.2
50	600	4.1	1.6	1.0	0.7	0.6	0.5	0.4	0.4	0.3
100		8.2	3.1	2.0	1.4	1.1	0.9	0.8	0.7	0.6
150		12.3	4.7	3.0	2.1	1.7	1.4	1.2	1.1	1.0
200		16.4	6.2	4.0	2.9	2.3	1.9	1.6	1.4	1.3
250		20.5	7.8	4.9	3.6	2.8	2.4	2.0	1.8	1.6
300		24.6	9.4	5.9	4.3	3.4	2.8	2.4	2.2	1.9
350		28.7	10.9	6.8	5.0	4.0	3.3	2.9	2.5	2.3
400		32.8	12.5	7.8	5.7	4.5	3.8	3.3	2.9	2.6
50	700	4.8	1.8	1.1	0.8	0.7	0.5	0.5	0.4	0.4
100		9.6	3.6	2.3	1.7	1.3	1.1	0.9	0.8	0.7
150		14.3	5.4	3.4	2.5	2.0	1.6	1.4	1.2	1.1
200		19.1	7.3	4.5	3.3	2.6	2.2	1.9	1.6	1.5
250		23.9	9.1	5.7	4.1	3.3	2.7	2.3	2.1	1.8
300		28.7	10.9	6.8	5.0	3.9	3.3	2.8	2.5	2.2
350		33.5	12.7	7.9	5.8	4.6	3.8	3.3	2.9	2.6
400		38.2	14.5	9.1	6.6	5.2	4.4	3.8	3.3	3.0
50	800	5.5	2.1	1.3	0.9	0.7	0.6	0.5	0.5	0.4
100		10.9	4.1	2.6	1.9	1.5	1.2	1.1	0.9	0.8
150		16.4	6.2	3.9	2.8	2.2	1.3	1.6	1.4	1.2
200		21.8	8.3	5.2	3.8	3.0	2.5	2.1	1.9	1.7
250		27.3	10.4	6.4	4.7	3.7	3.1	2.7	2.3	2.1
300		32.7	12.4	7.7	5.6	4.5	3.7	3.2	2.8	2.5
350		38.2	14.5	9.0	6.6	5.2	4.3	3.7	3.3	2.9
400		43.6	16.6	10.3	7.5	6.0	4.9	4.2	3.7	3.3
50	900	6.1	2.3	1.4	1.1	0.8	0.7	0.6	0.5	0.5
100		12.3	4.6	2.9	2.1	1.7	1.4	1.2	1.0	0.9
150		18.4	7.0	4.3	3.2	2.5	2.1	1.8	1.6	1.4
200		24.5	9.3	5.8	4.2	3.3	2.8	2.4	2.1	1.9
250		30.7	11.6	7.2	5.3	4.2	3.5	3.0	2.6	2.3
300		36.8	13.9	8.7	6.3	5.0	4.1	3.6	3.1	2.8
350		42.9	16.3	10.1	7.4	5.8	4.8	4.1	3.6	3.2
400		49.1	18.6	11.6	8.4	6.7	5.5	4.7	4.2	3.7

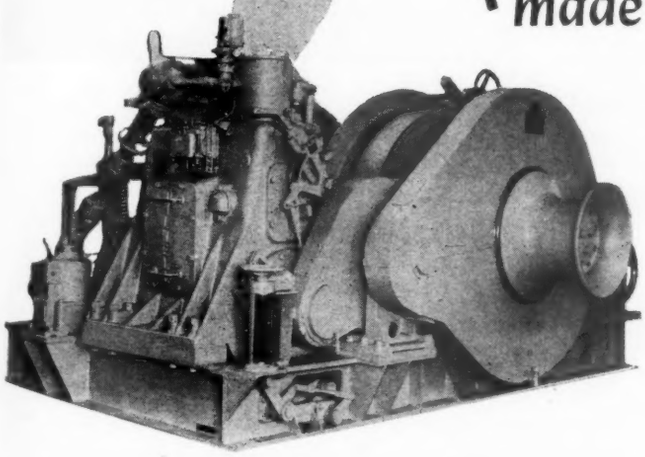
[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into the velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the no. of atmospheres.

Across the Straits of Mackinac





the Johnson Winch made "THE BIG PULL" possible



The *Johnson-Type* Series 238 Automatic Steam Winch demonstrated its tremendous power when it was pressed into service after the main winch, which had been built especially for the job, broke down and could not be repaired readily.

The project involved the pulling of a 20″ pipe almost four miles across the Straits of Mackinac which at one point is 243′ deep, making it the longest and deepest pipe line water crossing ever attempted by the pull method. With only 2,450′ of the four mile stretch hauled by the other winch, the "238" was set up at Point McGulpin to pull the 1,700 ton pipe line the balance of the way while a similar *Johnson-Type* Winch stationed at Point LaBarbe maintained tension and held the pipe on a steady course along a 10-foot channel. When this was completed without difficulty, a second pipe of the same proportions was laid nearby to finish the job.

Built in this country for the Lakehead Pipeline Co. of Superior, the construction of this pipeline was under the technical supervision of the Bechtel Corp. of San Francisco with the underwater crossing by Merritt-Chapman & Scott Corp. of New York.

This *Johnson-Type* Automatic Winch is but one of a full line of Marine Auxiliaries using either steam or electric power. Though employed primarily in the marine industry, its part in this epic making project presages its use on any venture demanding such exceptional ability.

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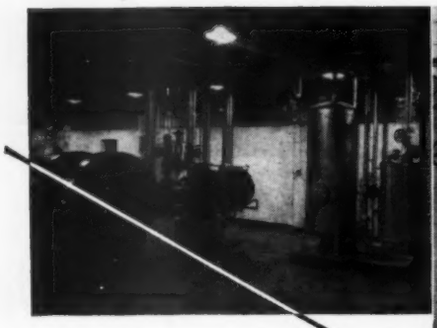

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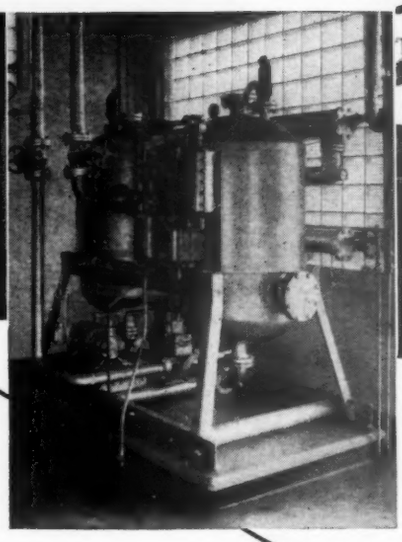

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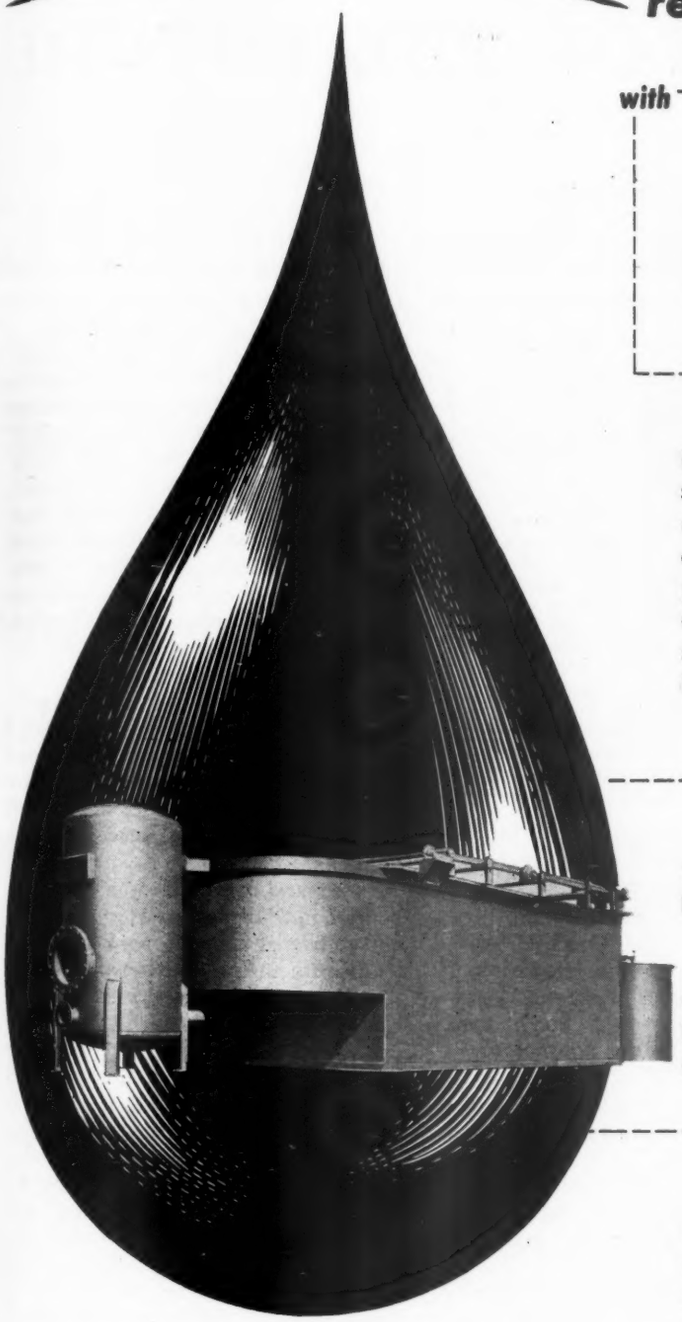

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Demand for natural gas has surged upward in recent years when reserves were increasing less rapidly. An industry leader warns we must think now about —

NATURAL GAS FOR THE FUTURE

HINES H. BAKER

NATURAL GAS for the future in this country is today an important consideration. As late as 1920, only one twenty-fifth of the energy consumed in the United States was natural gas. Today it supplies more than one-fifth, or half as much as oil and more than half as much as coal. The demand is increasing faster than proved reserves. Hence both the consumer and the distributor have reason to share with the producer concern regarding future supplies. All are of necessity interested in promoting conditions that will assure these supplies.

The change in the relationship between the demand for natural gas in the United States and natural gas reserves has been most pronounced since World War II. Since 1945, the demand doubled, while proved reserves increased by only one-third. By 1952, proved reserves were near a level of 20 times the annual rate of production, which is perhaps as low as desirable from the standpoint of assuring adequate supplies for the future. Furthermore, if the same rate of growth in demand and in proved reserves experienced during the past six years should continue, proved reserves by 1958 would be only 15 times the annual rate of production. This prospect is not unlikely in view of recent predictions that a practically unlimited demand for gas may occur in the next ten years. Such a development would pose a major problem with regard to adequate supplies of natural gas for the future.

A look at the price of natural gas over a period of time and at the relationship between such price and the prices of coal and oil reveals a reason for this situation. The retail price of natural gas today is approximately the same as it was in 1939, while the prices of coal and heating oil have doubled. Notwithstanding its cleanliness, convenience, and greater efficiency, gas is being sold to consumers at retail in many large cities, including some in important coal producing states, at a lower price per million British thermal units than heating oil or coal. It is being sold in the field by the producer at a price equal to about one-fourth the price of fuel oil at Gulf Coast refineries and about two-fifths the price of coal at the mine. The cost of producing natural gas has risen greatly and is continuing to rise. In the light of these facts, it is not difficult to understand the rapid growth in the demand for natural gas and the slower rate of increase in proved reserves.

The meaning and significance of these facts in relation to future supplies of natural gas are not generally appreciated.

The problem of adequate future supplies is greatly aggravated and made doubly serious by reason of continuing threat of regulation by the Federal Power Commission of the producers' field price of gas moving interstate. In fact, the commission is already regulating the charges for gas produced by natural gas companies on the basis of a fixed return on the depreciated investment in producing properties. The threat is that this regulation may be extended to the independent producer of gas, who is in no sense a public utility.

Before examining the nature and effect of this threat if made effective, let us look at the nature and operation of the natural gas producing business.

Members of the American Gas Association are fully familiar with public utilities, with their nature and the effect of public regulation. The gas distributing companies have long been recognized as public utilities and have operated under state and municipal regulations. Likewise, the interstate transmission lines transporting gas in interstate commerce and selling it for resale by distributors have been regulated as public utilities under the Natural Gas Act passed by Congress in 1938.

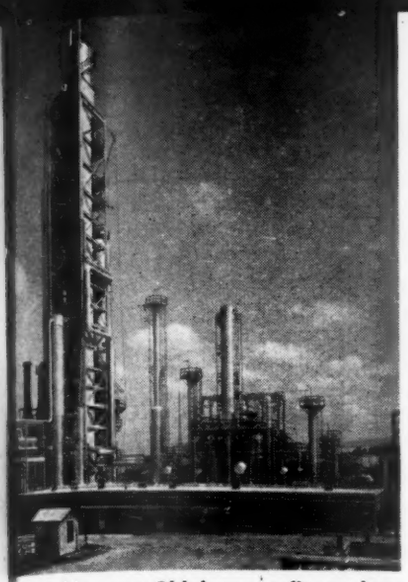
As you know, a public utility usually operates under a public franchise or a certificate of public convenience and necessity. It is granted certain exclusive rights to serve the public, holds itself out to perform these services to the public, dedicates its property to this purpose, and is protected against competition in whole or in part in its chosen and restricted field of operation. After its investment is made, it enjoys a reasonably stable business with more or less fixed risks that can be fairly well measured, and is entitled by law to have its rates regulated so as to yield a reasonable return on the investment. Because of the heavy investments involved and the necessity of securing the services required in the public interest, competition is restricted, and the rates are regulated to protect the public against unreasonable charges and at the same time provide a fair return on the public utility's investment.

The business of producing natural gas has none of these characteristics of a public utility. It is highly competitive; there are no franchises or certificates of public convenience and necessity that give one producer preference or a protected area of operations or that restrict competition or afford a monopoly. The risks are much greater. In fact, to those who enter the business there is no assurance of any return on investment; and often the entire investment itself is lost without any

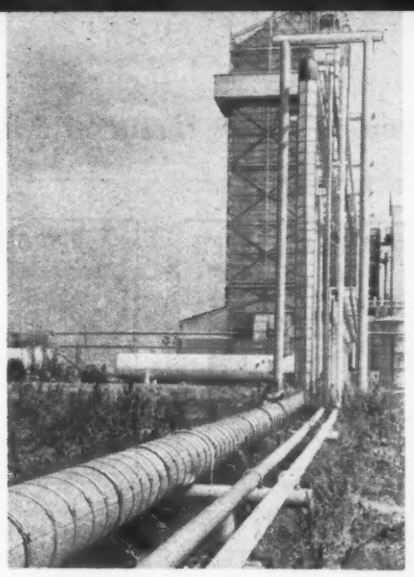
The Author

Hines H. Baker is president and a director of Humble Oil and Refining Company. A graduate of the University of Texas, Baker began the practice of law with Foster and Hardwicke in Beaumont, Texas, and, in 1919, became a member of the firm of Baker and Baker. From 1919 to 1937 he was a member of Humble's law department. He has been a director since 1937, vice president from 1941 to 1945, executive vice president from 1945 to 1948, when he was elected president.

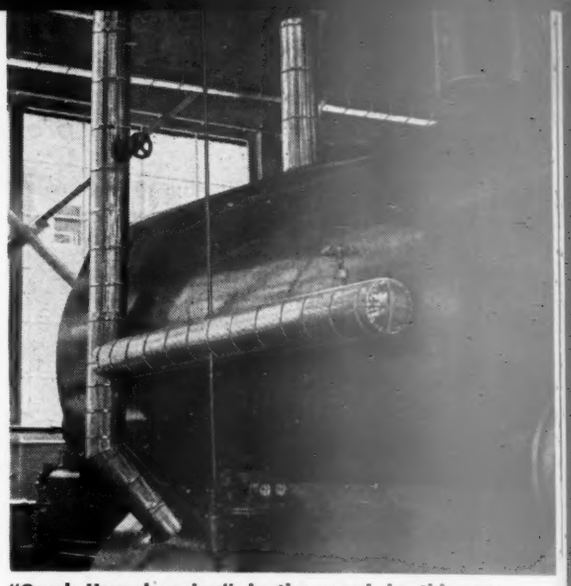
†Address delivered before American Gas Association, St. Louis, Missouri, October 28, 1953.



This big new Oklahoma refinery has used a new kind of aluminum jacketing throughout on both insulated lines and towers and vessels. Light in weight and low in cost, this new Childers Aluminum Jacketing cut installation costs. It is also expected to cut maintenance costs.



Childers Aluminum Jacketing is used here on a cross-country transfer line at a large chemical manufacturing plant in Texas. This is a rugged test for any jacketing, but the light-weight aluminum used in this jacketing should stand up to weather and chemical corrosion it encounters.



"Good Housekeeping" is the word in this gas pipeline pump station. The insulated lines are handsomely protected by Childers Aluminum Jacketing, which should last as long as the plant itself. The jacketing requires no painting and very little other maintenance. It even allows the interior of the plant to be washed with a hose without harm to the insulation. The chief engineer reports: "We have standardized on Childers Jacketing for all our insulated lines. It is doing an excellent job for us and saving us money."

How 5 plants cut costs of jacketing insulated lines

Weather-resistant, low-cost, easy to put on—these are big reasons for the growing popularity of a new jacketing, specially engineered for insulated lines. It is made of .006" thick aluminum and comes with or without a moisture barrier. It is called Childers Aluminum Weatherproof Jacketing. You can write for a free sample without obligation.

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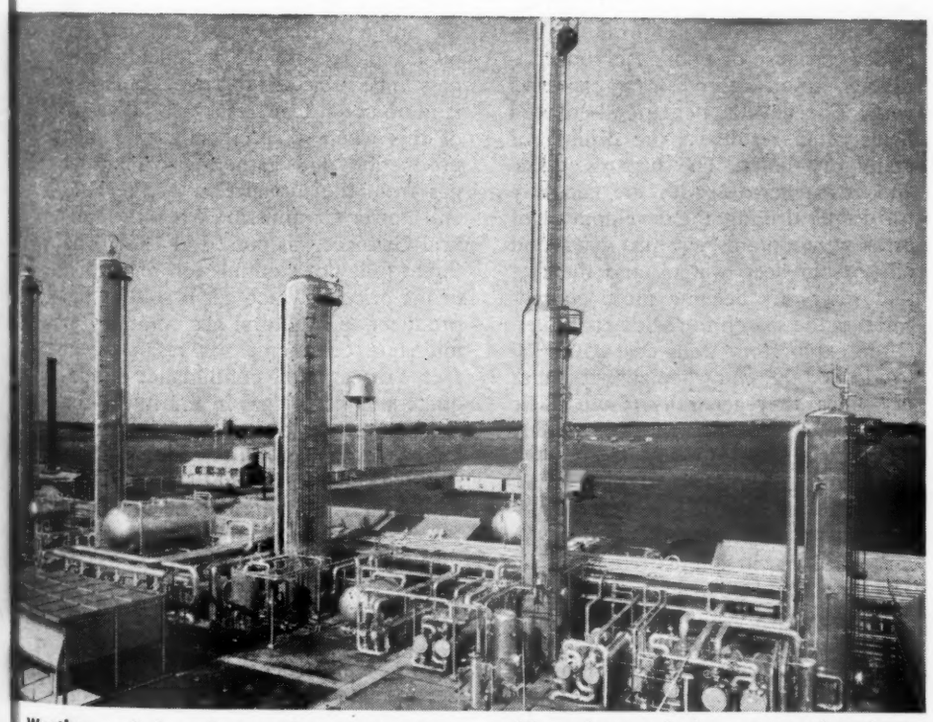

Weather, wind and corrosive gases are not going to attack the insulation of this new plains-country gasoline plant. The insulation is protected by long-lasting aluminum: Childers Aluminum Weatherproof Jacketing. The management expects this low-cost jacketing to hold insulation maintenance costs to a minimum. Other advantages are that the jacketing went on quick and easy during construction; it required no special tools or skill — no shop forming or cutting. It can be taken off and re-used if lines are moved. Aluminum saves on painting and the tough 3S alloy used for Childers Jacketing should stand up for years even in highly corrosive industrial atmospheres. Check the advantages of this jacketing for your own plant.

Amazingly easy to handle, Childers Jacketing was applied here by men using no more than a wooden wedge and a pair of pliers. Childers has engineering representatives in every major industrial center who will be glad to confer with you on your particular jacketing problems. Write to address shown above.

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return. There is no holding out to serve the public in a specific operation and no dedication of properties to a public use as is the case with public utilities. Under these circumstances, no basis exists under our competitive enterprise system to regulate the gas producing business as a public utility.

The business is not similar to the operation of railroads, bus lines, telephones, electric power, or natural gas distribution. These are recognized public utilities regulated both in the interest of the public served and of the investor and the operator of the business. The natural gas producing business, on the other hand, is similar to other mining ventures in the high risks involved and similar to these and to agriculture and manufacturing in the prevalence of competition. In these competitive industries with which it is similar, there is no assurance of any fixed percentage of return on investment.

Hence, there is no more occasion to regulate the business of producing natural gas or the price of such gas when sold by a producer than there is to regulate the price of coal or iron at the mine, oil or sulfur at the well, cattle or sheep at the ranch, the products of the factory. These prices are controlled by the forces of supply and demand through competition in a free market. The public is protected by this competition from exhorbitant prices; and the businessman engaged in these ventures gains his incentive to invest and work in the hope of satisfactory returns by offsetting losses on one venture by success in another. This is the time-honored American way. It has resulted in high productivity in all lines, and has brought us through progress to the economic well-being we enjoy today.

The business of producing gas is closely related to the oil producing business. They are generally carried on together, as any well may produce oil or gas or both if it is not a dry hole. Both are highly competitive in the search for prospects, the purchase of leases, the drilling of wells, and in seeking markets. There are some 5000 individual units engaged in the gas producing business; and new ones are free to enter the business at any time without the grant of a franchise.

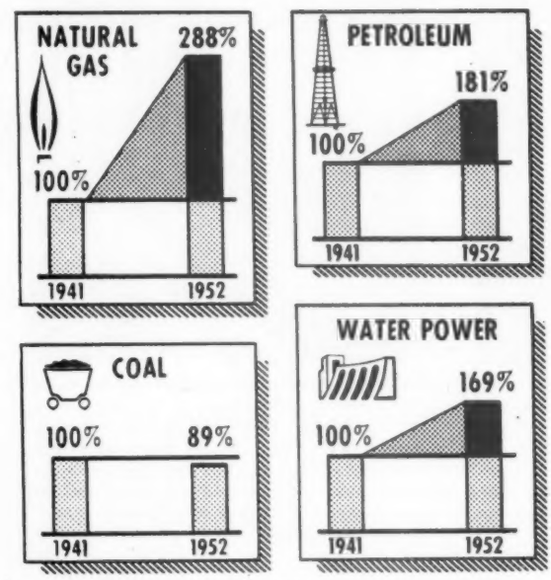
The business is characterized by great risks. Despite the technical improvements in geologic and geophysical methods of locating structures favorable to the accumulation of oil or gas, only drilling can determine whether these products underlie any location. Of every nine exploratory wells drilled, only one on the average discovers oil or gas, and only one in forty-four finds an oil field with a reserve as large as a million barrels. Many discoveries are not profitably operated, because of poor reservoir conditions, small reserves, or excessive costs. The development of discovered fields often results in the drilling of many dry holes. The hazards, risks, and costs increase with the necessity for deeper drilling, the development of areas in mountains, swamps, bays, and offshore in deep waters, and the fact that reservoirs become more complicated as the search for fields continues. Often exploratory wells cost $500,000 to $1,000,000; and when abandoned as dry holes, they generally result in the surrender of leases on the surrounding area at great loss of investment.

To compensate for these risks, to induce investment of new capital and reinvestment of profits, the returns on successful ventures must be attractive. They must be sufficient to pay for exploration expense and all the unsuccessful ventures and yield such a profit as will induce the operator to risk investments in new ones. The risks are too great to secure the necessary expenditures for exploration and development on the basis of a fixed percentage return on the investments in the successful ventures. The natural gas required to meet the demand cannot and will not be discovered and produced under such regulation.

Because of this inherent nature of the business it is definitely against the public interest for the producing business to be subjected to price regulation. And no doubt Congress was well aware of this when it specifically exempted production and gathering of natural gas from the jurisdiction of the Federal Power Commission when the Natural Gas Act was passed in 1938. The threat today of Commission regulation of the price at which gas is sold by the producer to a natural gas company in interstate commerce for resale is, in fact, a threat to the continuance of adequate supplies of gas in the future for the natural gas companies engaged in interstate transportation and sale of gas, the local distributors of gas, and finally the American gas consumers.

Let us examine this threat more specifically.

The Natural Gas Act was designed to met a specific problem. The gas companies engaged in the local distribution of gas to consumers were subject to state and municipal regulation as public utilities. Their rates were fixed by public authority. Production was subject to state regulation for conservation purposes. But the gas transmission companies, engaged in transporting gas from the fields where pro-



SOURCE: AMERICAN GAS ASSOCIATION

Last year, natural gas contributed nearly nine quadrillion Btu of energy, almost 23 per cent of the nation's total supply and about triple its use a little more than a decade ago. This amount of energy is sufficient to make 245 million automobiles or total output of cars for 35 years at present rate of production.

duced to the city gates and selling it to the distributing companies, were not subject to effective state or municipal regulation because they were engaged in interstate commerce. The Natural Gas Act was enacted by Congress in response to requests for regulation of charges by these interstate utilities. The Act was not intended nor designed to regulate local distribution at one end or production and gathering at the other end. In fact, both were expressly exempted from the jurisdiction of the Commission. It was designed to fill the gap between these by regulating natural gas companies in the interstate transportation of natural gas and sale thereof to distributors for resale.

Notwithstanding the exemption and early holding by the Commission itself in the Columbian case[1] that it had no jurisdiction over production and gathering and the producers' field price, it has gradually encroached into this field. It began by including gas reserves owned by natural gas companies in the rate base of those companies and permitting only a percentage return (about 6 per cent) on the depreciated cost of such reserves. In these cases valuable gas reserves were taken into the rate base at nominal values only.[2] This step was wholly unnecessary and unsound. The Commission clearly had authority to prevent natural gas companies from charging as an expense gas produced by them and taken into the trunk lines at a price higher than the competitive going price in the field or its fair and reasonable value. This would have protected the distributor and consumer fully. At the same time it would have assured the gas company as a producer of receiving the equivalent of the competitive field price, which would have placed it in the same position as the independent producers in each field.

The Commission next took jurisdiction over the field price charged by a natural gas company for its own production in an independent arm's length sale to another natural gas company, which moved the gas interstate for resale. This action was upheld by the courts in the Interstate case.[3] During these developments, however, the Commission disclaimed any intention of taking jurisdiction over the price charged by an independent producer in an arm's length sale to a natural gas company for resale and so held in a number of cases. In 1947, it issued an order to the effect that it would not exercise jurisdiction in such instances.[4]

[1]In the matter of Columbian Fuel Corporation 33 P.U.R. (N.S.) 3 (1940).
[2]See Federal Power Commission v. Hope Natural Gas Co., 320 U. S. 589 (1944); Colorado Interstate Gas Co. v. Federal Power Commission, 324 U. S. 481 (1945).
[3]Federal Power Commission v. Interstate Natural Gas Co., 331 U. S. 682 (1949).
[4]Order No. 139, issued August 7, 1947.

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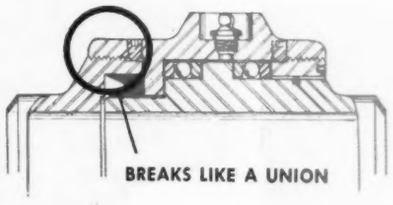

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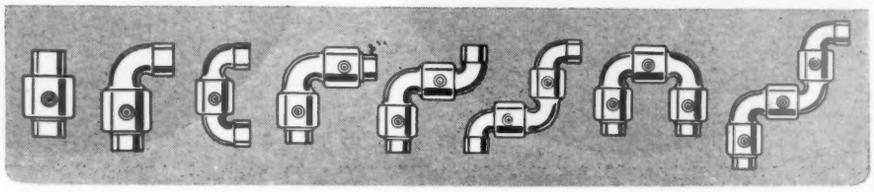

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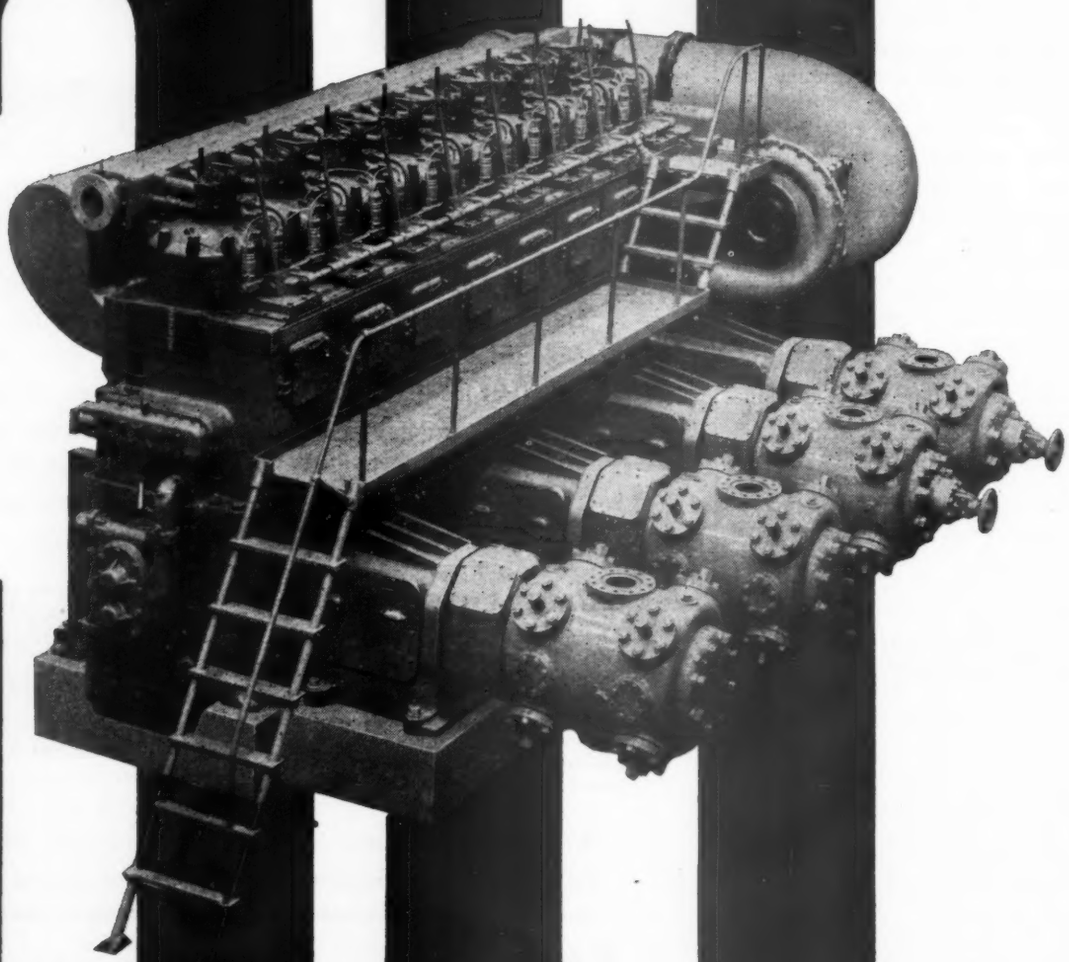

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In 1950, Congress enacted the Kerr Bill expressly denying jurisdiction in the Commission in such cases. This was vetoed by the President. Thereupon, the Commission revoked its 1947 order, and announced that investigations would be made of sales by independent producers where the price appeared excessive.[5] It investigated the charges made by Phillips Petroleum Company for gas in or near the fields where produced in sales to natural gas companies. Upon review, however, in July 1951, the Commission found that under the Natural Gas Act it had no jurisdiction, because the sales were a part of production and gathering.[6]

This holding was reversed by the Circuit Court of Appeals for the District of Columbia upon an appeal there by several consumer cities.[7] The case is now before the Supreme Court.[8]

That case may determine in similar fact situations that the Commission cannot regulate field prices charged by an independent producer. It may hold that the Commission has authority to regulate such prices. It will not in any event free the natural gas company from Federal Power Commission control of the value at which it takes the gas from its own producing properties into the trunk line. In its producing activity the natural gas company is not performing a public utility function. It is competitive with other non-utility operators engaged in producing gas. It takes the same risks. Equity and consistency require that it be given the same treatment as the independent producer. And thus the price at which gas production of the regulated company goes into the trunk line following production and gathering should be the going competitive field price, or if there is no such price, then its fair and reasonable value based on the nearest competitive conditions.

Federal Power Commission control of the field price for natural gas is unsound and against the best interests of the consuming public and against the general welfare for many reasons:

1. Control of the producers' field prices by the Commission would appear to be contrary to the intent of Congress when it enacted the Natural Gas Act, based on a consideration of the legislative history of the Act and upon the express provision of the Act itself exempting production and gathering of natural gas from the Commission's jurisdiction. The field sale is a necessary incident to production and gathering; control of this is the most effective control possible over these operations.

2. Production of natural gas is a highly risk-taking venture, actively competitive, and wholly different in character from a public utility business properly subject to rate regulation. Government price regulation is no more applicable or suitable to it than to oil at the well, coal at the mine, livestock on the ranch, or the products of the factory. Price regulation of competitively produced commodities is basically wrong in principle and can only serve to hurt the interests of the consumer as well as of the producer. Furthermore, and equally important, any attempt to regulate gas prices on the basis of cost plus a fixed return on investment would result in a chaotic diversity of price that would discourage producers from selling gas in interstate commerce, encourage the inefficient, and penalize the efficient. Prices would have to be determined for thousands of producers, some of whom operate hundreds of leases in many fields.

The inefficient, high-cost producer would be rewarded with the highest price and profit while the efficient producer would be discouraged by the lowest price. Everyone would want to buy the cheap gas; and no one would want the most expensive gas. Some purchasers would be forced to buy the high priced gas, while others would be allowed to enjoy the advantage of the low priced gas. Such a system would be unsound and unsatisfactory. The only fair and sound principle of price determination for a competitively produced commodity, such as natural gas, is to allow the forces of supply and demand in a free market to set a general market price.

3. Government regulation will not serve to protect the interests of consumers as well as will competition. Competition among thousands of natural gas producers in a free market provides the best safeguard against unreasonable prices. This would be true for natural gas companies, for distributing utilities, and for the ultimate consumer.

As in the past, purchasers of gas will shop around for the cheapest supplies they can find, just as producers will search for markets paying the best prices. Such a competitive system will determine the proper price level to balance supply and demand continuously. Under the competitive conditions that have existed, gas has sold in the field at ridiculously low prices.

Much of it is still being bought at

[5]Order 154 issued July 11, 1950.
[6]In re Phillips Petroleum Company, FPC Docket No. G-1148, Opinion No. 217, July 18, 1951.
[7]State of Wisconsin v. Federal Power Commission, 205 (Fed. 2d) 706 (1953).
[8]Subsequent to the delivery of this address, the Supreme Court on November 30 refused to review the case. This emphasizes the conclusion stated that Congressional legislation is required to resolve all of the issues involved.

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depression-level prices under twenty-year contracts, negotiated when there was a surplus of gas and when costs were a fraction of what they are today. These low prices have prevailed only because gas has too often been considered a by-product. The producers selling at these prices could not stay in business or afford to continue the search for gas but for the fact that they rely on their oil operations to carry the burden of their heavy exploration and development costs. Now, we cannot supply enough gas to meet demands as an incident to our search for oil. The demand for gas is increasing faster than the demand for oil. If demands are to be met, gas must begin to bear its share of exploration and other petroleum industry costs. Strong demand will inevitably act as a force to raise prices; but the encouragement to the search for new supplies as a result of better prices will bring forth additional supplies and thus will just as assuredly act as a force to keep prices reasonable. Under current conditions of supply and demand, gas prices may be expected to rise from the depressed levels at which they have been selling; but they will still be reasonable so long as they are determined under the free operation of supply and demand by competition among gas producers and competition of gas with coal and oil. The entire history of our country proves that competitively determined prices are the best means of assuring consumers of adequate supplies at reasonable prices and of stimulating producers to greater efficiency and efforts to satisfy their customers.

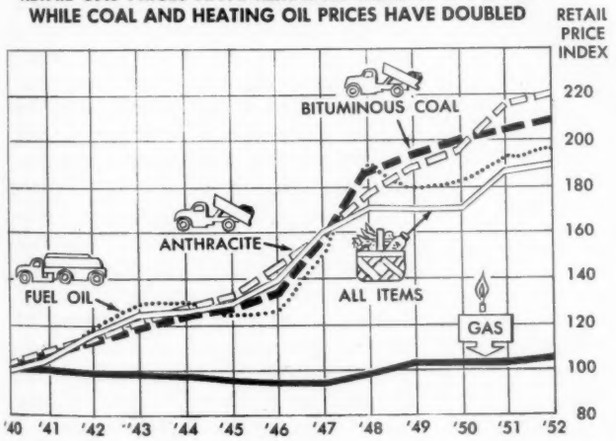
4. Artificial control of the producers' field price for gas will lead in time to shortages and to higher prices. Regulation of price on the basis of costs will not bring forth adequate supplies of gas. This has been demonstrated by the fact that regulated natural gas companies have contributed very little to meeting the additional requirements of their customers, and have been forced to turn instead for the additional supplies to producers who have not been regulated as to price.

Judging from experience of the natural gas companies, government regulation of price would be based on the investment in successful ventures only without regard to the large amounts of capital that have been risked and lost in exploration and unsuccessful ventures. Attempts to allow for these factors for petroleum producers would inevitably raise the question as to what part of exploration expense, dry holes, and surrendered leases should be borne by gas instead of oil and lead to control of oil as well if these factors are to be taken into account. If the successful ventures alone are considered, producers would be more apt to lose than make money under government regulation because of the risks involved. They would certainly not be able to borrow or attract outside capital under such conditions. Consequently, new supplies of gas would diminish and shortages would develop. In such cases, producers would concentrate on selling available supplies within the state where it is produced, and would reduce their sales in interstate commerce as their contracts expire. With the growth of industry in the Southwest, intrastate sales of gas may be more attractive than interstate sales if the field price is regulated on such sales. Shortages resulting from regulation of the field price of gas would thus have their major impact on interstate sales.

On the other hand, under a system of competitive price determination in a free market, producers will be encouraged to adjust their search for new supplies to changing demands, regardless of whether those demands go up or down. In such a situation, supplies will be adequate to meet demand and both intrastate and interstate markets will be satisfied. Only if we avoid the threat of regulation of the field price of gas can we hope to succeed in preventing shortages.

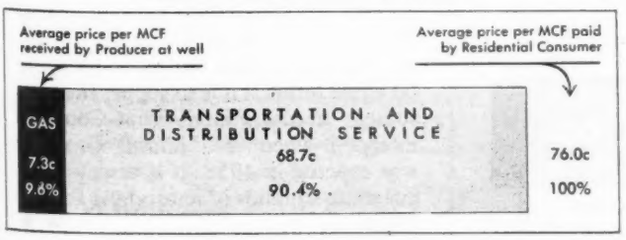
5. Regulation of the producers' field price of gas would in time mean

RETAIL GAS PRICES HAVE REMAINED ALMOST THE SAME WHILE COAL AND HEATING OIL PRICES HAVE DOUBLED

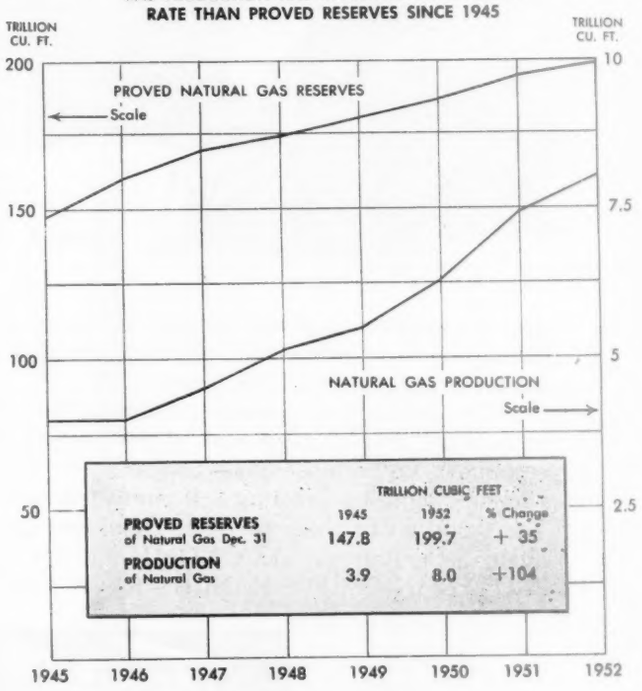


Source: Gas Facts 1952, American Gas Association.

THE PRODUCER RECEIVES SMALL PART OF THE PRICE PAID BY THE RESIDENTIAL CONSUMER



GAS PRODUCTION HAS INCREASED AT A FASTER RATE THAN PROVED RESERVES SINCE 1945



TRILLION CUBIC FEET	1945	1952	% Change
PROVED RESERVES of Natural Gas Dec. 31	147.8	199.7	+ 35
PRODUCTION of Natural Gas	3.9	8.0	+104

higher prices to consumers. In the first place, such regulation would force the high-cost gas into interstate sales, for the reasons previously mentioned. There would be another effect, however, which would also tend to increase cost to the consumer. A shortage of gas would mean higher costs of transportation and distribution. Because of the large fixed investments involved in these public utility operations, a decline in the volume of business handled means a corresponding rise in the unit cost. If pipe lines can operate at or near capacity, their cost of transportation per unit of gas moved is much less than if they operate at only part of capacity. The same principle applies to distribution costs. A shortage of gas would thus tend to increase the costs of transportation and distribution, which today account for 85 to 90 per cent of the delivered price of gas to the residential consumer. Thus, the application of public utility regulation principles to gas production, which as heretofore stated has none of the characteristics of a public utility business, would in time defeat its alleged purpose of protecting consumers and actually result in much smaller supplies as well as in higher delivered prices for gas.

There is need to remove the uncertainties and correct the inequities that exist regarding the extent of jurisdiction and authority of the Federal Power Commission over production and gathering of natural gas and the producers' field price of such gas. The exercise of control over the production and gathering activities of natural gas companies and the return from the producing operations has already discouraged their finding and development efforts. The threat of such control over independent gas producers has materially restrained the sale of natural gas for movement in interstate commerce for resale. It will reduce exploration and development. The problem cannot be solved by administrative action. Such action may vary widely with changes in personnel and administrations. This has occurred frequently in the past. There is no assurance that the favorable attitude of the present Commission may not be changed by a later one. The Phillips case pending in the Supreme Court cannot resolve all these issues. Nothing short of congressional legislation can resolve them.

The solution of this problem lies in congressional legislation which expressly prevents the Federal Power Commission from

(1) regulating the production and gathering of natural gas;

(2) fixing or regulating the price at which the producer or gatherer of natural gas sells his gas to a natural gas company;

(3) fixing the rates of a natural gas company below a figure that will allow as an expense the actual price paid for gas purchased from non-affiliates, or the market price or fair and reasonable value in the field considering market conditions of that produced by the natural gas company or acquired from an affiliate, plus reasonable compensation for gathering.

Such legislation will release the productive forces of our free competitive enterprise system, will thereby encourage the risk of venture capital in the finding, developing and producing of natural gas, and will provide conditions favorable for bringing forth the quantities of gas required over the long run to meet the needs and demands of the American consumer. Over the long pull, the gas producing industry, regulated as a public utility and held to public utility returns will not be able successfully to compete with oil or coal for a place in the supply of energy for the Nation. It must be free to compete on equal terms if it is to supply the consumers' needs. That is what Congress intended when the Natural Gas Act was enacted in 1938. It is essential for adequate supplies of natural gas for the future. * * *

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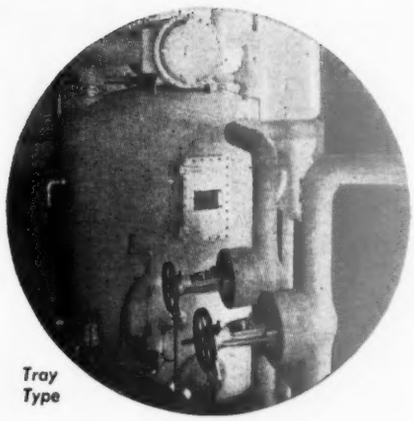
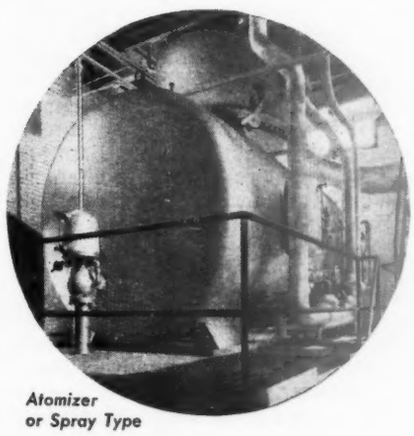
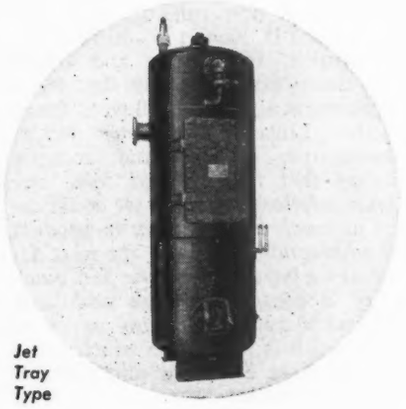


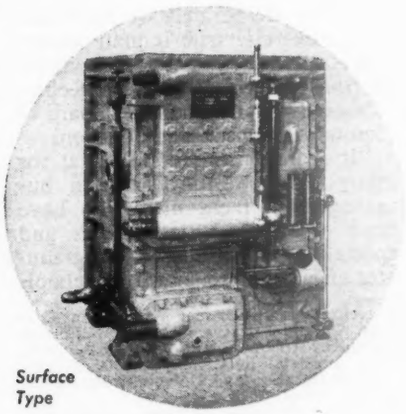
Tray Type



Atomizer or Spray Type



Jet Tray Type



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MANAGING THE MODERN MAN†

Human needs are more than economic but when fulfilled results will show vast improvement in product and production costs

EARL G. PLANTY*

IT should be unnecessary to more than mention the need for building teamwork and cooperation in American business and industry. That full cooperation and teamwork should exist is an unquestioned axiom of management —that it does not exist is an equally well-known fact. Labor disputes, strikes, employee apathy, indifference and even resistance are reported all too fully and frequently in the press.

Even in the best of industries *full* cooperation and top productivity are almost never attained, and in most cases the production values of full cooperation go unrecognized even among good supervisors and executives. There are, however, a few business leaders whose vision has outlined the future attainable if we will only rebuild the conditions that will create the full cooperation once prevailing in business and industry but now missing. Men like Henry Ford II, Robert Wood Johnson, McCormick, Bill Given and others have described the happy day when management and labor will work freely together. Lincoln, the electric welder manufacturer of Cleveland, recently claimed that *if we could solve our human relations problems we could expect as much improvement in product and production costs over the next decade as we have made in the past quarter of a century through technical, mechanical and engineering advancements.* Such is the future which some industrialists envision and toward which they work.

This future will be attained only through the efforts of executives who know and practice what is right about people. How desperately we need men who can exercise true human leadership is attested by a quotation from the book *But, General Johnson* by Robert W. Johnson, Chairman of the Board of Directors of Johnson and Johnson:

> "It is important to note that for many years we have chosen our management from men who have been educated as technicians and specialists. Unfortunately the graduates of our great engineering schools and the products of our American universities were not equally well educated in the great science of human engineering. Recently it has become apparent that the greatest technical skill is worth little unless men and women can be persuaded to carry out the decisions essential to making that skill effective. We are now discovering that a scientific and technological understanding of a subject does not of itself develop or produce ability to lead large groups of people into enthusiastic day-in and day-out response. This means that we must have new management—management not only skilled in the techniques but equally well grounded in the field of human relations.'

Providing or creating this new management skilled in human relations is difficult. We know too little about people, including ourselves as well as others, and we know almost nothing about how to teach this modicum to others. Throughout America there is a willingness, even an eagerness, to give lip service to the importance of human relations and the need for leadership and instruction in these fields, but I do not find many educators or administrators who know what constitutes good human relations, and I find fewer who know how to teach others what little they do know about the subject.

Basic Human Relations Credo

At Johnson and Johnson we have therefore given considerable attention to discovering what it is that is basic to the creation of cooperation and teamwork. We have arrived at two simple conclusions:

1. Any person who finds out what it is that other people want—that is, their basic social and psychological needs—and helps to provide for those needs can lead people to full production, free cooperation, and personal satisfaction.[1]

2. All people have social, psychological, and emotional wants, no less demanding in their requirements for satisfaction than the need for food and sleep. These needs are those of belonging, recognition, security, and new experience.[2]

Managements and supervisors must learn how to satisfy these needs in the daily operations and contacts of the office and the shop, if they are to create the stable, productive, cooperative team of workers required for the bright future predicted by our leaders.

Feeling of Belonging

First among the social needs of all people is that of belonging. People need to belong—to be a part of things. People are gregarious, they are joiners. Hitler recognized this and provided for it in his leadership. He reminded the German people of their culture, their art, and their science. He paraded their books and literature and music. He emphasized their "superior" Nordic stock and compared their biological inheritance and physical strength with that of the "weaker" Southern Europeans. Soon he had popularized a myth of German supremacy. He told the Germans that they belonged to a greater Germany, a new Germany. He invented or rediscovered the swastika. He got together bands and parades and all the paraphernalia to celebrate German ancestry and power. He rebuilt the country and developed a political credo—that of the Nazi Party—to which he encouraged them to subscribe. Once he had built up the strong emotional ties between the people and his concepts about Germany, they were ready to follow his leadership fully, freely, even to their own death and almost world-wide destruction.

Great leaders realize this power that lies in the feeling of belonging. Franklin D. Roosevelt created a "New Deal." He referred to the voters as "my friends," had fireside chats with them and they belonged to him and followed his leadership through all the elections in which he stood as a candidate. He gained this position of leadership by inviting people to join with him in a program of better things for all. In his talks and writings, he shared his goals, his aims, with people. People want to be a part of things—to belong, to be accepted, to share in decisions affecting them.

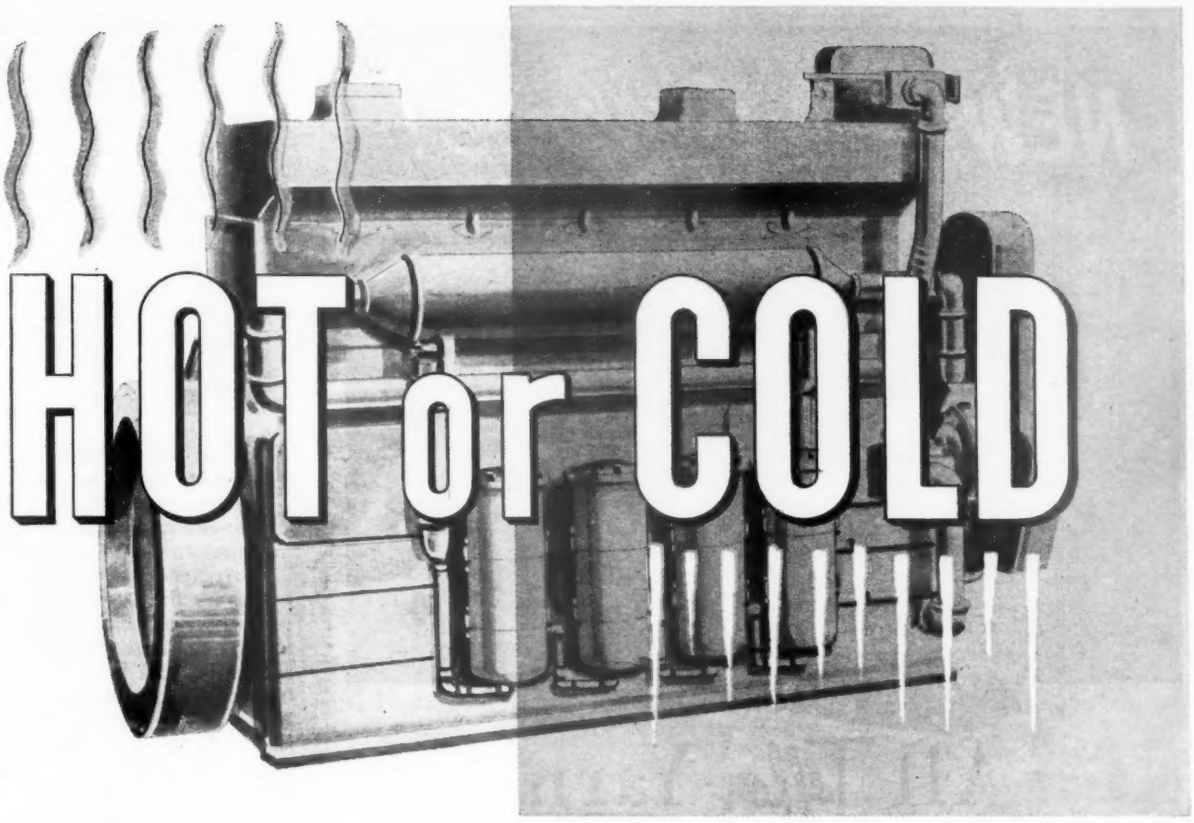
Leaders in industry can win an

†Presented before Summer Management Conference, Yosemite National Park, California, sponsored by University of California's Institute of Industrial Relations, Schools of Business Administration and University Extension, September 16-19, 1953.

*Executive Counselor, Johnson & Johnson, New Brunswick, New Jersey.

[1]See: Chapter VII, "Motivation in Social Behavior," *The Development of Human Behavior* by Richard Dewey and W. J. Humber.

[2]The need for new experiences is not discussed in this paper.



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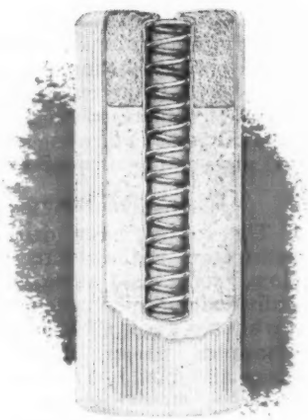

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emotional attachment for the company if they will find the means of telling employees about the company, its history, its early leaders, its policies. They must discuss in conferences, in company publications, and through plant broadcasting systems the product which is produced, its ultimate use, its quality, and its cost. They must raise problems facing the company and invite employee opinions about their solution. In short, they must make workers proud to be part of the business. This management can do by telling them about the company's aims, objectives, methods and products, and about the workers' contribution to the success of the business.

Too many managements in America today are, however, expecting employees to play on the free-enterprise team and reject Communism or other destructive movements, without telling their players the signals for the game.

To play any position on an athletic team, one must know what the plays are to be and how each player contributes to the success of the venture. Workers must know their signals no less certainly than athletes. They must know the production standards, the distribution of the sales dollar, the company's economics, advertising campaigns, contemplated expansions, new products, and all policies and practices affecting them or their work. To inform them on these questions will help to create the powerful emotional feeling known as "belonging"—a feeling which satisfies the employee and evokes cooperation, productivity, and responsibility.

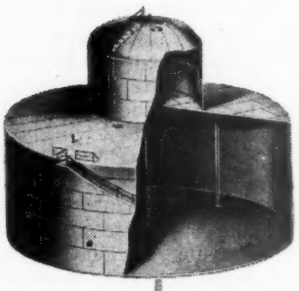
Being told what is going on and why goes far toward creating identification. Some business leaders are ready to go further—to invite employee participation in problem solving, a device of greatest value in creating both the feeling and the actuality of belonging.

Desire for Recognition

The second basic drive requiring satisfaction is the desire for recognition. People need to be recognized as individuals. Supervisors and co-workers should know their employees' and associates' names, should speak to them, and should be familiar with their interests, strengths, and weaknesses. Nothing builds cooperation in a man faster than the knowledge that his superior knows his strengths and will use them, knows his weaknesses and will help him to overcome them. All people need this recognition and *they need it continually*.

In recent weeks an executive told me about a subordinate of his, whose only function was the writing of reports. The executive said that six months ago he had called the man into his office and had complimented him on a report he had written, but the executive was annoyed at the thought of repeating the interview. "Must I do this continually?" he asked. This question makes clear how little we know of human relations. The executive might

the HAMMOND DIALIFT*



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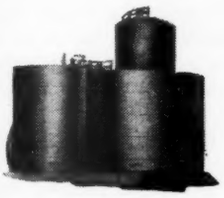
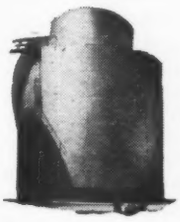
The Hammond DIALIFT is the modern tank for eliminating breathing losses and reducing filling losses. It gives maximum conservation of vapors at lowest cost.

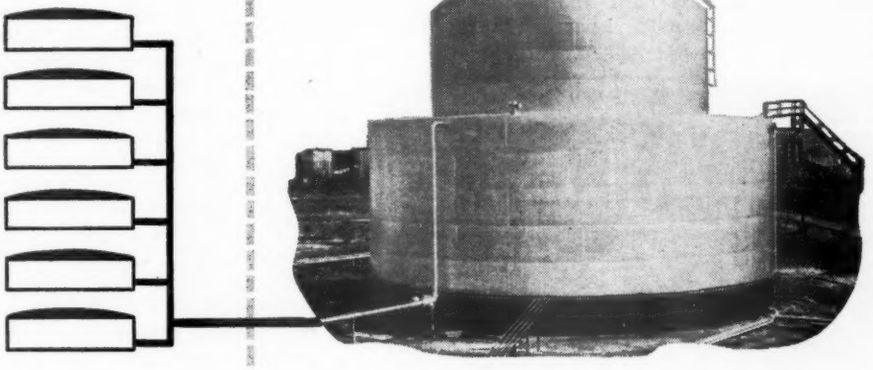


42'6" x 40' Liquid Storage Tank
22' x 17'9" Dialift. Housing — 6500 cu. ft. capacity Inter connected to a 25' x 40' Cone Roof Tank



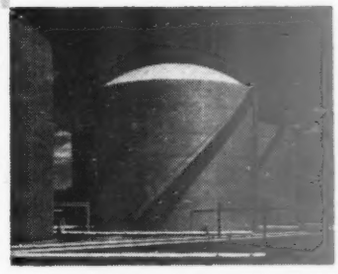
50' x 48' Liquid Storage Tank
30' x 15'9" Dialift. Housing — 12,500 cu. ft. capacity

The DIALIFT consists of a tubular membrane attached gas-tight to the inside periphery of a cylindrical housing. In operation the DIALIFT functions as the lung of the storage tank. The membrane lifts under a slight pressure when additional vapor storage space is needed, and lowers when less vapor space is required; self-adjusting to the constantly changing breathing conditions within the tank.



80' x 30' Liquid Storage Tank
35' x 17'9" Dialift. Housing — 20,000 cu. ft. capacity

It is easy to convert an existing Cone Roof Tank to an efficient DIALIFT installation. A DIALIFT housing is superimposed on the existing roof, breather holes are installed through the roof plating permitting a free passage for all vapors, no other preparation is necessary.



60' x 48' Ground Type Dialift.
150,000 cu. ft. capacity

*patented

Bulletin 53DL details and describes the Hammond Dialift . . . *Write for your copy.*

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just as well have asked, "Is it necessary for this man to sleep more frequently than once every six months, or to eat more often?"

The social and psychological needs require satisfaction just as frequently as the physical needs.

The need for recognition is partly satisfied in industry through athletic teams and clubs, through provision of clean and respectable work places, cafeterias, comfortable rest rooms, vacations, service awards, buttons and pins, pictures and stories about employees in the company newspaper, suggestion awards, merit rating systems, policies encouraging promotion from within, training programs, etc.

In one of our plants we have used plant broadcasting to help provide recognition. Our own employees write the scripts and put on the shows. Sometimes their efforts are directed to pure entertainment, sometimes to instruction. Frequently they help to solve troublesome and persistent management problems concerning housekeeping, safety, absenteeism, waste elimination, cost reduction, and installation of new methods. The scripts are very brief and are put on sometimes during the lunch hour, sometimes during working hours. They frequently satirize or burlesque actual situations.

In one case employees were leaving their work places, when the quitting whistle blew, in too rough and rapid a manner, so that they were injuring one another and breaking equipment in their rush to get to the time clocks. The workers developed a skit in which three popular employees were brought individually before the microphone. The first was interviewed with his arm in a sling. He said he had been injured in an auto accident, the details of which he related. The second one who came before the microphone and told his story was an armless veteran recently released from a naval hospital. The third person came before the microphone in a wheelchair. His face was swathed in bandages so that the announcer had to push away the bandages to recognize him as the plant superintendent. When the announcer asked him whatever calamity had befallen him, the plant superintendent merely said, "I was walking along here yesterday just in front of that time clock when the quitting whistle blew."

In thus sharing the responsibility for the solution of management problems with employees, the plant recognizes workers as able to contribute to management no less than executives and supervisors do. When recognized, simply and inexpensively through plant broadcasting, employees have revealed a startling interest in correcting faults in their own behavior and in cooperating fully with management.

Need for Security

The next basic requirement of all people is security. Security means reasonable freedom from worry, fear, anxiety. It means, of course, economic security as well as social and emotional security, but in past we have placed all our emphasis upon economic aspect. It is not enough to pay good wages.

We must assure our workers that employment will be continuous, that no hard-boiled supervisor will dismiss them without cause. We must assure them that their working conditions will not be a hazard to their health and welfare. If we are to make our workers secure, we must find their strengths and capitalize upon them. We must transfer workers freely who are in positions where they are failing or are likely to fail. We must let our workers know that the boss is interested in them, has their welfare at heart, knows their needs and will, so far as he can, provide for them. In fact, some experts say that those are secure who are loved and wanted.

Above all, we must let them know what is going on, for this is the primary way to dispel the rumors, fears, and suspicions which spring up where there is insecurity. A president once said, "We have nothing to fear but fear itself." These may well be remembered as his greatest words. To eliminate fear from the minds of our employees, we must inform them fully and often about working conditions, company services and benefits, expansion plans, employment stability and all the factors, economic and social, which influence their present or their future. To do this we must use many group meetings, company publications, bulletin board campaigns, plant broadcasts, and frequent informal contacts between supervisors and workers. The difference between the fearful, frightened savage, relying upon superstition and magic, and modern man, relying upon judgment, is knowledge. When one knows, he is more secure.

When the need of human beings for *belonging*, *recognition*, and *security* is as well recognized and provided for in industry and society as the need for food, drink, rest, shelter, and physical comforts, we will have a work force that can provide the production miracles of a prosperous future. Until that time comes we can expect four degrees of response from our employees, depending upon how well their supervisors and managers have or have not satisfied their basic needs. Where workers' social and emotional needs are neglected, we may expect (1) apathy, indifference, or disinterest; (2) grudging obedience or sudden cooperation; (3) negativism, suspicion, and overcritical attitudes; (4) antagonism, rebellion, and open conflict.

To avoid these reactions and to provide the creative, constructive, satisfying and productive ones which are possible, we must learn how to manage our plant and office relationships so as to satisfy the social and emotional wants of people more fully than we have in the recent past. ***

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IT PAYS IN MANY WAYS
to use Durametallic—the packing that is custom-built for your particular need. Durametallic packing provides better sealing, longer runs and less friction on your rods, shafts and stems.
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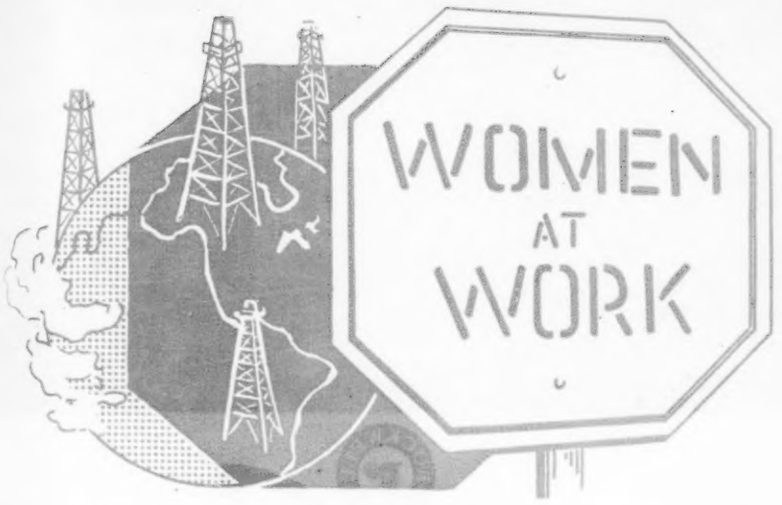


Irene Gadelman always picks winners.

Uranium Leasor

Frances Oldham is living proof that a woman can handle about any job given to her. This is the tribute of Bruce Anderson, independent operator, president of Eagle Oil Company, Casper, Wyoming, and Frances' boss.

Mrs. Oldham began with Eagle Oil as a secretary and she and the company have grown together. Today she is widely known as one of the most capable and highly paid women in Wyoming oil business. She has accumulated overriding royalties on thousands of acres. Last year her sale of overrides almost equaled her regular salary.

She has authority to buy and sell land when her employer is out of the office and has entered into a number of separate business ventures in his absence. She acquired a large number of uranium and vanadium leases on her own initiative and two years later Mr. Anderson became one of the owners of the American Uranium Company.

Fran does so many things that it is difficult to analyze her work. She is secretary of Eagle Oil Company, keeps the books and minutes of the corporation, issues and transfers all stock, supervises all other corporate matters, directs the general office routine, checks and keeps account of 20 or more separate sets of books, negotiates for notes and loans, keeps track of tax savings that might be instituted in the companies, and for variety, is a landsman.

"All this," says Mr. Anderson, "we admire in Fran, but most of all we appreciate her keen business judgment and her innate good sense. It is very difficult to describe common sense."

When Fran goes home it is another well-ordered organization that is the result of her tireless ability to manage things smoothly and sensibly. She and her husband, Barney, who originally got her interested in the oil business through his job as personal contact man for R. L. Manning Company, drilling contractors, own their home in Casper, and are proud parents of 6-year-old Pamela.

An alumna of Stevens College and the University of Colorado, Frances White Oldham is on the board of directors of the Casper Desk and Derrick Club, is past president of the Casper Business Women's Association, is a director of the American Red Cross, and chairman of the Natrona County Women's Division for Government Savings Bonds.

Rocky Mountain executive.

She Recommends Oil Business

Forty years in the oil business wasn't enough of a career for **Irene Gadelman.** She retired from Stanolind Pipe Line Company in 1949 and immediately set up a business of her own, Gadelman's Employment Service in Tulsa, Oklahoma.

Reared in Kansas, Irene graduated from high school at the age of 16 and was a school principal by the time she was 18. Then she described the teaching profession for the oil business. Her first job was secretary and bookkeeper in a combination oil-law-and-real estate office. The oil partner of the trio flourished, took separate offices and took the secretary. A few years later Irene joined Mutual Oil Company as secretary to the president.

In 1923 Irene came to Oklahoma and took a job with Henry L. Phillips, then president of Sinclair Crude Oil Purchasing Company. When Standard of Indiana bought out Sinclair's Purchasing and Pipe Line companies seven years later and Stanolind Oil Purchasing and Stanolind Pipe Line were formed, Irene stayed around to assist the new executives.

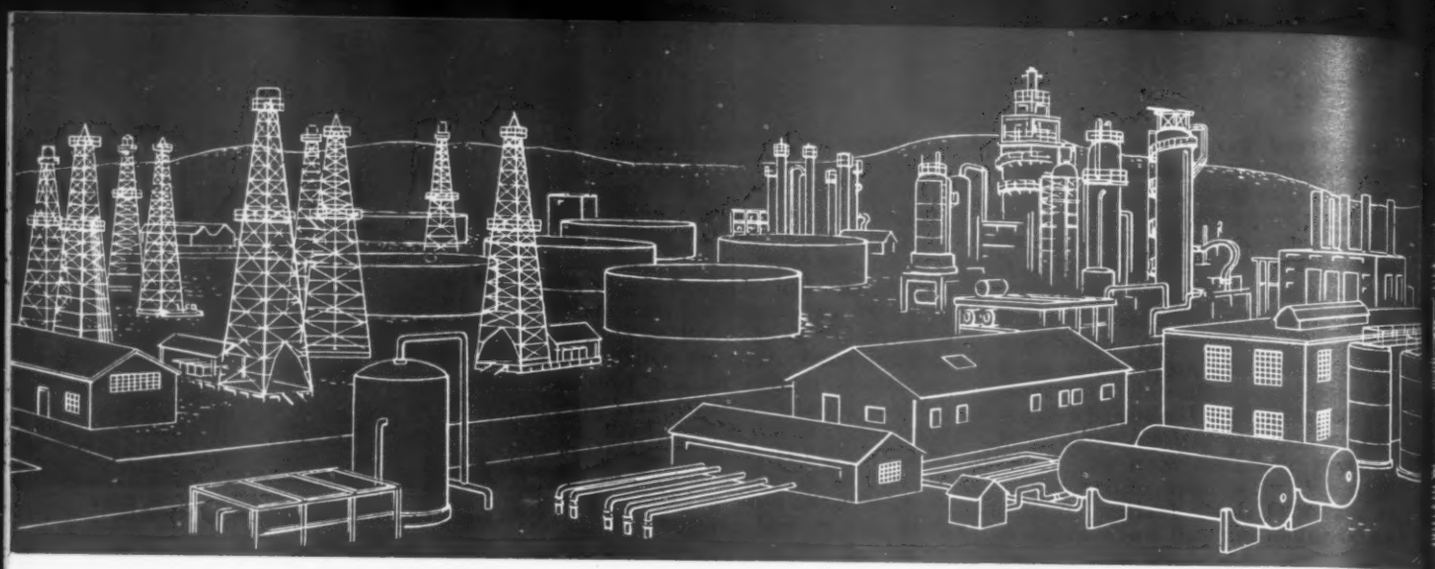
"I've loved my work," Miss Gadelman says, "and I've had the respect and cooperation of employers and associates. It's a joy to serve under such conditions."

Irene was named assistant secretary of Stanolind Pipe Line Company in 1946. She kept records, sat in on many board meetings, had charge of the executive payroll, assisted with the private payroll, and the annuity plan.

Versatile Irene always studied to stay abreast of new developments. She took many correspondence and night courses, and in 1935 went abroad for three months to tour Europe.

"I've always been a bit of an organizer," Irene relates, adding that she was one of the pioneers of the National Secretaries Association. She has successfully helped to organize everything from home owners to parties for service men and visiting engineers. One time she helped the late General Jonathan Wainwright judge a Texas State Beauty contest. Their selection copped the Miss America title.

On the night of her retirement, October 6, 1949, Irene Gadelman, guest of honor, danced the night away, filled a scrapbook with mementos, and promptly forgot about retiring. It was then she opened her own business. Now fledgling employees by the score come to her for expert guidance in their careers. It's no accident that the oil industry gets her best recommendation.



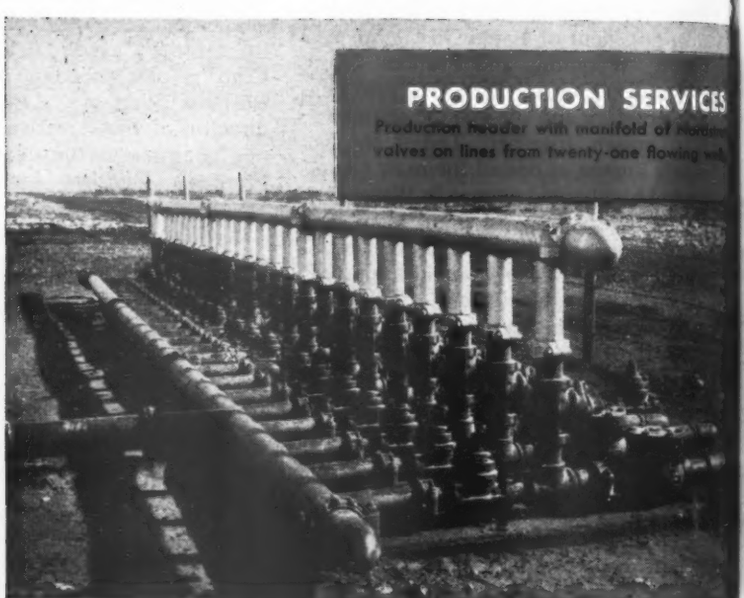
How Rockwell Serves T

CHRISTMAS TREES

Nordstrom valve-equipped Christmas tree on flowing well.

PRODUCTION SERVICES

Production header with manifold of Nordstrom valves on lines from twenty-one flowing wells.

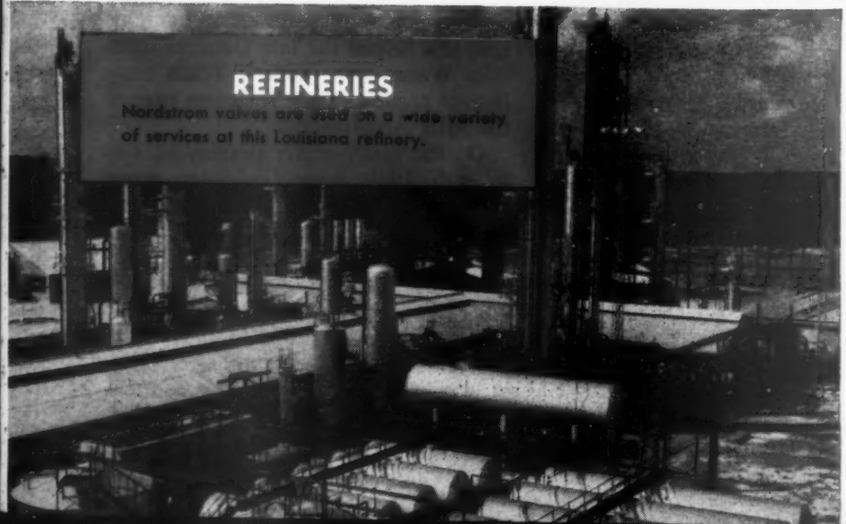


GASOLINE PLANTS

Nordstrom cylinder-operated valves on dehydrator lines in an Oklahoma gasoline plant.

REFINERIES

Nordstrom valves are used on a wide variety of services at this Louisiana refinery.



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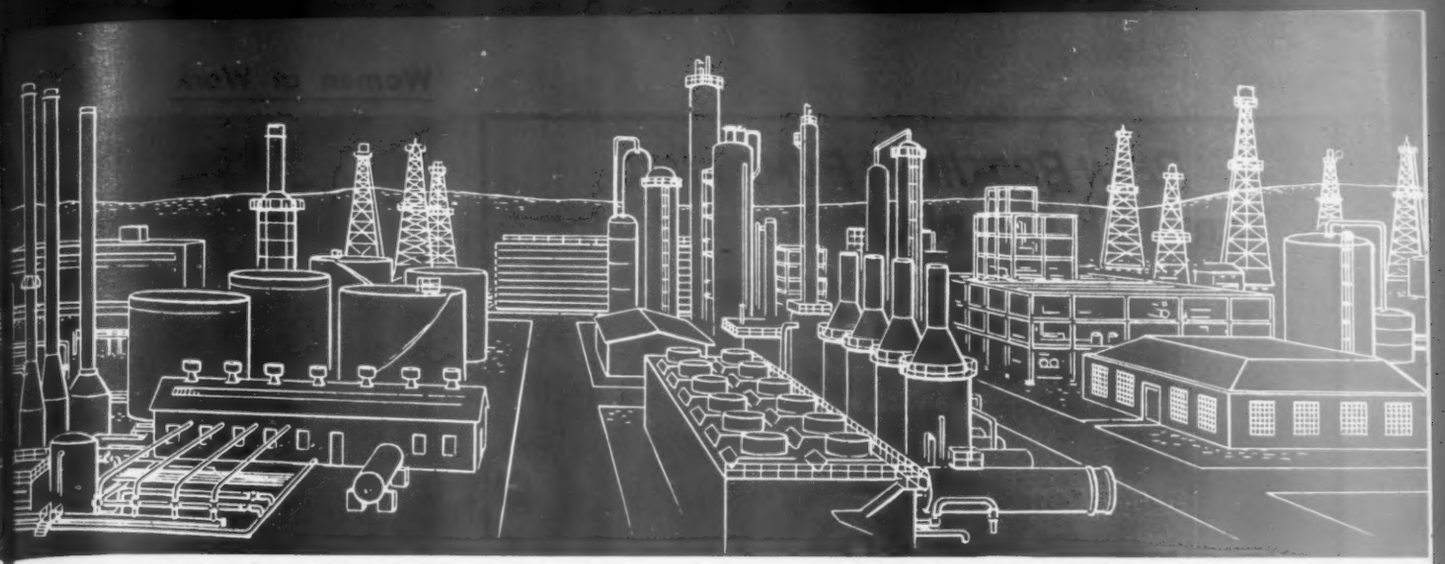

The Oil Industry...
FROM WELL TO CONSUMER

Rockwell products have proven their efficiency in hundreds of applications throughout the Oil Industry.

Nordstrom Lubricant-Sealed valves, Rockwell Rotocycle meters, and Rockwell Industrial meters are in operation on all types of Oil Industry services requiring accurate measurement and control.

For further information on Rockwell products, call your nearest Rockwell representative.

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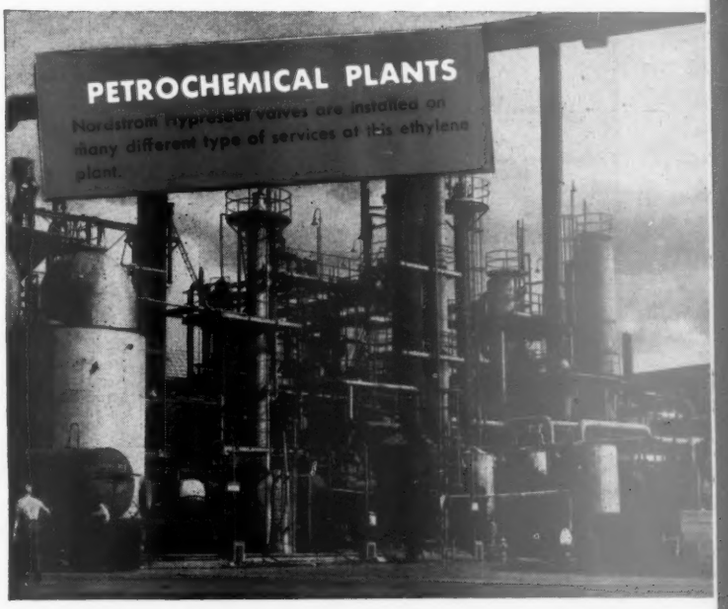
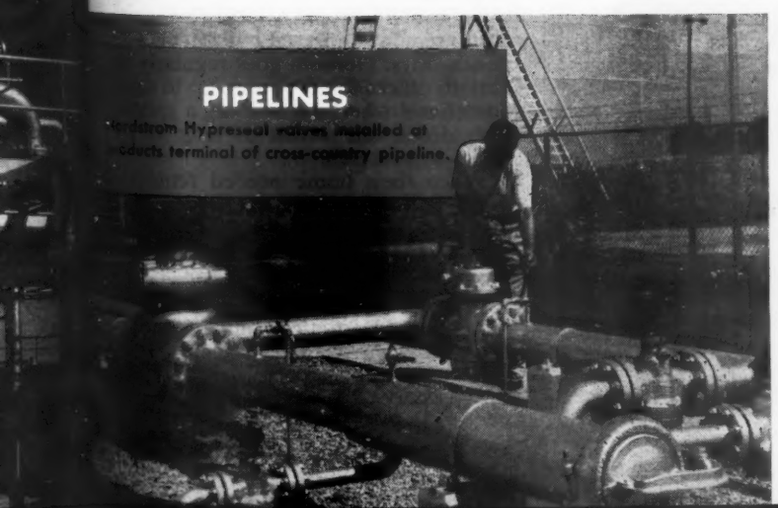

PETROCHEMICAL PLANTS
Nordstrom Hypreseal valves are installed on many different type of services at this ethylene plant.

ROCKWELL MANUFACTURING COMPANY

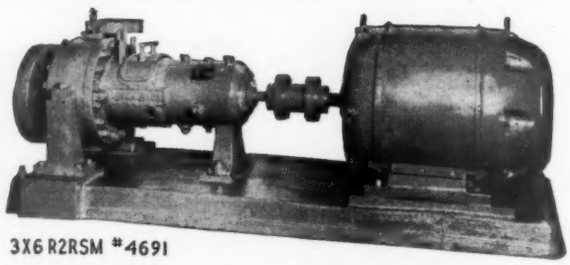
PITTSBURGH 8, PA. Atlanta Boston Chicago Houston Los Angeles
N. Kansas City New York Pittsburgh San Francisco Seattle Tulsa



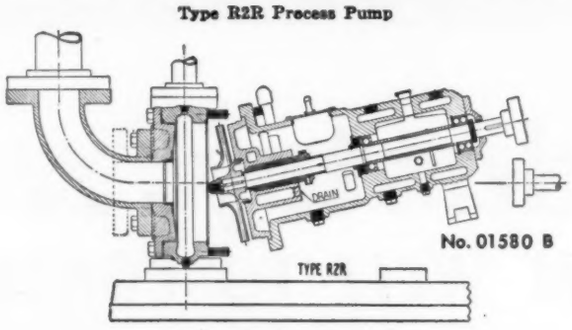
XUM

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

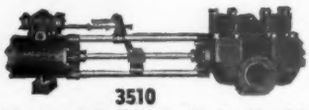
DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL AND RECIPROCATING PUMPS

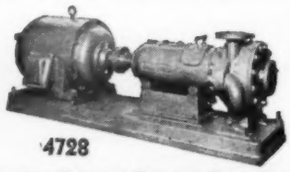
Close Coupled Centrifugal Pump



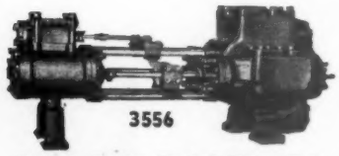
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

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Representatives in Principal Cities

Drafting was her entree

Has Her Own Business

Marilyn Gerdom is proof that a career and a home can mix — quite happily for all concerned. She is not owner of **a** business, but **two** businesses. She is not only a wife, but the mother of two little girls. She is also a top-notch cook, decorator, and hostess. Just past the quarter-century mark, she has accomplished all this at an age when most people are still wondering how to get started at a career.

Marilyn made up her mind early what she wanted out of life. When her father, H. C. Walker, started teaching her drafting, she decided that one day she'd have a business of her own. She finished high school, enrolled in geology and engineering courses at the University of Wyoming, financed part of her schooling by doing drafting. Then Marilyn married . . . had two children . . . filled in for a major oil company as a draftswoman on a part-time basis . . . but refused to give up her dream.

Last year, with the launching of The Gerdom Drafting Service, that dream came true. The business is headquartered in her home so that she can be with her children as much as possible. Founded with the idea of offering expert drafting service to independents and others who do not have full-time help, the business has grown beyond her imagination. Included with it is a secretarial service that began when Marilyn learned that many firms needed temporary office help and many girls needed temporary jobs. Five assistants are now employed in the two businesses. Mrs. Gerdom goes regularly to various offices to keep maps up to date. Sometimes when she is doing a special rush order, she works as long as 14 hours at a stretch.

When their home needed remodeling, W. K. and Marilyn Gerdom did the work. He wielded the tools and she did the decorating and painting.

Most of Marilyn's other outside activities — square dancing, bridge, ceramics, and decorating candles — have had to give way to her business and home life, but she manages time for the Casper Desk and Derrick Club.

DIGS 17¾ ft. BELOW GRADE

With long, deep reach—17 feet-9 inches below tracks—and fast, clean dump, this Koehring ½-yard hoe delivers big output on trenches, footings, firewalls, slush pits and other below-grade excavations. Heavy-duty boom resists side-sway—holds the line in toughest digging. Dipper won't turn away from the cut because wide boom-point provides a rigid connection to the dipper arm. You get a straight, clean cut every time.

Digging angle of the hoe dipper is easily changed to best suit the type of material and cut being made. Three settings are provided by adjusting-links on the dipper arm. During the dig-and-swing cycle, the close-coupled dipper pulls up tight to boom, avoids spillage as boom is raised.

Full operating efficiency is maintained at all times because all main clutches are self-adjusting. Heat-compensator springs make tension changes automatically. There's no time-out for continuous manual settings. This saves time, pays off in improved control and extra production with every 205 attachment. This Koehring ½-yard hoe readily converts to shovel, dragline, clamshell, crane, pile driver. As a crane it lifts 10 tons on crawlers . . . also available on rubber-tired truck mounting. See Koehring distributor or write for more information.

K369

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Personals

▸ **Eugene Holman** has been named chairman of the board of directors, Standard Oil Company (New Jersey), succeeding **Frank W. Abrams,** retired, and **M. J. Rathbone** as president and as vice chairman of the executive committee. Holman, who remains chief executive officer of the company, and chairman of the executive committee, has been president since 1944, and Rathbone a director since 1949.

Eugene Holman

M. J. Rathbone

The company also announced the election of **Chester Smith,** a vice president and director, to the executive committee, and the election of **Lloyd W. Elliott,** a director, as a vice president to succeed **Orville Harden,** who retired.

In view of Abrams' deep interest in the promotion of higher education and his special interest in Syracuse University, his alma mater, the company announced that it was making a payment of $100,000 to the university in his honor.

Abrams joined the company as a draftsman in 1912, and 19 years later he was manager of the Eagle Works of the Pakersburg, West Virginia, refinery as well. When a Jersey affiliate, now Esso Standard Oil, was formed in 1927, Abrams was elected to its board of directors and six years later became its president. After three years, he was elected a member of the board of Standard of Jersey, vice president in 1944, and two years later chairman of the board of directors.

Holman joined Humble, a Jersey affiliate, in 1919 as a geologist and was assigned to the north-central Texas oil fields shortly after receiving a master's degree in geology from the University of Texas.

Named a director of Jersey in 1940, he was elected a vice president in 1942, and later a member of the executive committee. He took over the presidency of the company in 1944, and in 1946 became chairman of the executive committee.

Rathbone, a graduate of Lehigh University, joined the Jersey organization 32 years ago as an engineer at the Baton Rouge refinery of Standard Oil Company of Louisiana. He rose to general superintendent of that plant and later became president of Louisiana Standard. In 1944, when that company was merged with Esso Standard Oil Company, he went to New York as president of Esso Standard.

Smith was first employed by the company in 1908, and has been continuously associated with the company since his graduation from the University of Pennsylvania in 1913. He was elected to the Jersey company board in 1944 and became a vice president in 1946.

Elliott was president of Standard-Vacuum when he was elected to the Jersey board of directors in 1951. He got his start in the oil business in Tulsa, Oklahoma, in 1916, when, still in preparatory school, he joined Carter Oil, a Jersey affiliate.

Harden, retiring after a long and distinguished career with the company, was the youngest man ever elected to Jersey's board. He started with the company in 1910 as an office boy. He was elected a director in 1929 at the age of 35. He became vice president in 1935 and since 1942 has been vice chairman of the executive committee.

▸ **B. A. Otis, Henry Power,** and **Herman W. Taylor** of the General Petroleum Corporation have retired. Otis was manager of the company's land department and has been with General Petroleum since 1925. An engineer and geologist, he worked in both capacities in his career with General Petroleum.

Power, staff engineer in General Petroleum's production department, had been with the company since 1919. He has held his present position since 1942.

Taylor joined the old Standard Oil of New York, a predecessor of Socony-Vacuum, in 1913. He worked in lubricant and industrial sales until 1948, and since that time he has been in administrative work connected with gasoline and fuels sales.

▸ **F. W. J. (Billy) Haas,** the first man to open a Houston office for Shell Oil Company, has retired after almost 40 years with that organization.

It was in April, 1922, that Haas and his boss, F. B. Plummer, rented two rooms at 1215 Louisiana to serve as the first Shell offices and living quarters as well.

For the past several years Haas has been in charge of drafting for Shell's technical services division.

▸ **William J. Barnett** has been promoted to second assistant manager, production department, Caracas. He was formerly head of pipe line section, production department, Caracas.

Stephen P. Bredin, was named industrial relations supervisor, Caracas district. He was formerly acting industrial relations manager, Amuay.

Herbert Bernard Hegglund is new assistant division manager, Maracaibo. He was acting assistant division manager, Maracaibo.

Hubert J. Polk, is new administrative assistant, production department, Caracas. Prior to his promotion he was district superintendent, Caripito.

▸ **Walter N. Bercaw** of Standard Oil Company has retired after 36 years' service. **L. J. Frodin** will succeed him as superintendent in the industrial relations division of the general office manufacturing department at Chicago.

▸ **H. M. Bayer** was elected a vice president by the board of directors of Gulf Oil Corporation. He will be in charge of the company's Fort Worth production division, succeeding F. P. Adams, retired.

A veteran of 29 years with the production division of the Gulf Companies, Bayer, a geologist by education and training, has a wide knowledge of exploration, oil production, and oil company administration. Prior to his election as a vice president he was manager of exploration in the company's Fort Worth production division. Bayer's business life and service to Gulf began in 1924.

INTERNATIONAL GUESTS at recent meeting of Los Angeles Nomads, are: Back row, Ray Reed, Maracaibo Towing Company, Venezuela; K. H. Brown, Basra, Iraq; John F. Knowles, Shell de Colombia, Colombia; Harry G. Bartlett, Dunlap and Graham, Peru; M. R. Vollmer, Ideco, Venezuela; Robert Schmidt, PREPA, France; F. S. Fobes, Baker Transworld, Canada; Weldon B. Troop, Gulf, Kuwait; John F. Drake, Bahrain, Bahrain. Middle row: Mark R. Teague, BPC, Iraq; Harry D. Huskey, Iraq Petroleum; C. L. Rynd, Babco, Bahrain; Fred Lay, MPC, Iraq; W. C. Schmittou, Venezuela; Maxwell Burgett, IPC, Iraq; G. N. Akin ex-IPC, Iraq. Front row: Mostafa Sharivar, Iran; Muhyi Lassim, Bagdad; Yacuoby Shahin, Kirkuk; Hamid S. Mohammed, Kuwait; Jose Oppes, YPF, Argentina; Charles Hadlow, El Salvador.

A major oil refining company on the eastern seaboard is building a catalytic reforming plant with capacity of 17,600 barrels per day....

. . . and PETROCHEM-ISOFLOW Furnaces will charge this 17,600 bpd plant.

A major oil refining company on the Texas gulf coast is building a catalytic reforming plant with capacity of 21,000 barrels per day....

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. . . and PETROCHEM-ISOFLOW Furnaces will charge this 21,000 bpd plant.

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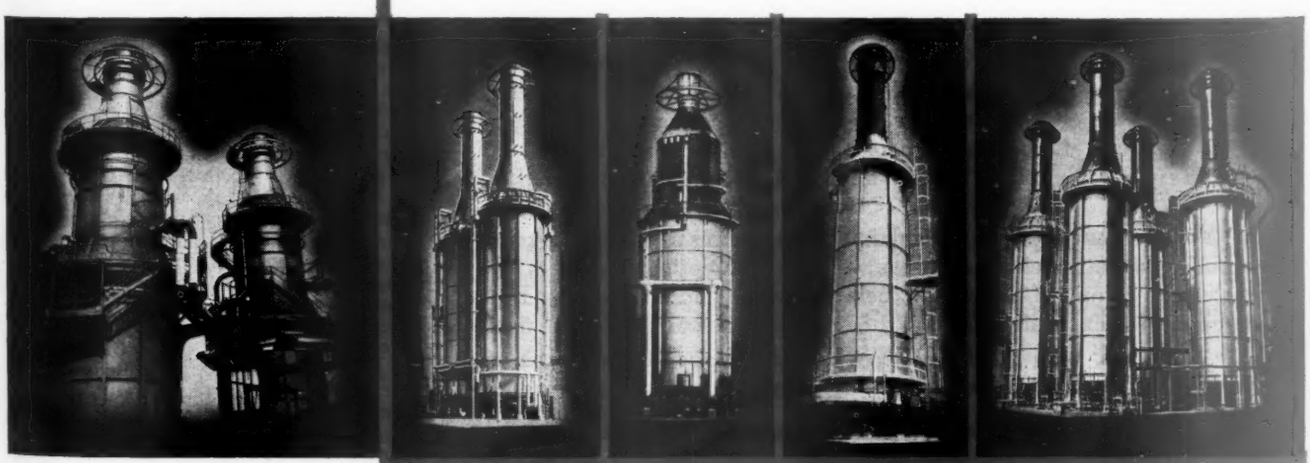
Our first cat reformer heaters went into operation three years ago. Since then, we have sold catalytic reforming heaters for plants ranging from 1,000 barrels to 21,000 barrels per day. If you anticipate the installation of a catalytic reformer of any type, you will profit by investigating PETROCHEM-ISOFLOW heaters for this service.

More than 1150 Petrochem-Isoflow Furnaces are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all

Petrochem-Isoflow Furnaces are most efficient by any comparison.



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In fact, our entire line of rigid hanger assemblies, overhead roller assemblies, vibration eliminators, as well as the functional hangers, are furnished as complete units . . . thereby saving you engineering time and eliminating expensive cutting, threading and assembling in the field.

Our engineers, who have had years of experience, are available to both design and make recommendations for your hanger requirements.

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BLAW-KNOX **PIPE HANGERS**

Complete line of functional spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated power piping systems for all pressures and temperatures.

Personals

G. A. Davidson

G. A. Davidson has been elected to succeed **B. W. Letcher** on the board of Standard Oil Company of California.

Letcher, with the company 43 years, began as a clerk following his education in San Francisco schools. He also has been a director for several years of Aramco and Tapline.

Following graduation from the University of California in 1920, Davidson joined California Standard as a chemist. He advanced through various positions to become superintendent of the El Segundo refinery, near Los Angeles, in 1933.

Wallace E. Avery has been named assistant secretary of The Texas Company. Avery has been with Texaco since 1945, and since 1951, has been assistant general manager of the company's industrial and public relations department. Prior to that, he served as an attorney in the company's Los Angeles offices.

Avery attended the University of California. From 1933 to 1942, he was engaged in legal work in the petroleum industry. From 1942 to 1945, he was principal attorney and later assistant chief counsel for the Petroleum Administration for War in Washington, D. C.

R. E. Wright has been named representative of Texas Petroleum Company at Lima, Peru, with the title of assistant manager. He was transferred to his present post from Caracas, Venezuela, where he was assistant to the manager of Texas Petroleum Company, a wholly-owned subsidiary of The Texas Company.

Willard Grant, who has been chief accountant at Bogota, Colombia, succeeds Wright as assistant to the manager at Caracas.

Wright joined the company in 1946. He is a graduate of Loyola University. Grant joined the company in 1946. He is a graduate of Northwestern University.

Frank M. Dawson, who has been with The Texas Company and associated companies for the last 25 years, has been named manager of the purchasing department. Since 1946, Dawson has been vice president and later executive vice president and director of Carthage-Hydrocol, Inc.

A graduate of Rice Institute, he began his service with Texaco as a chemist at the Port Arthur Works in 1928. In 1942, he became superintendent of the refinrey of an associated company in Buenos Aires, Argentina. In 1945, he was named superintendent of the Lawrenceville Works.

Charles M. Brooks has been named director of industrial relations for Texaco. Brooks joined The Texas Company in 1948, as staff attorney in charge of labor law. Since then, he has been closely identified with the company's industrial relations affairs and is well-known as an authority on employer-employee relations.

Personals

C. L. Orn

Clayton L. Orn has been named general attorney of Ohio Oil Company. Presently division attorney at Houston, Texas, Orn will move to the general office at Findlay, Ohio, to assume the newly created position in the company's legal department.

W. Hume Everett, division attorney at Casper, Wyoming, will become division attorney at Houston, succeeding Orn.

John W. Gee, attorney at Casper, will succeed Everett as Casper division attorney.

Orn has served Ohio Oil as division attorney at Houston, Texas, since joining the company in 1942. He previously engaged in private law practice in Fort Worth.

Everett returns to Texas where he practiced law in San Antonio for about 10 years before joining The Ohio Oil Company in 1941 as division attorney at Casper, Wyoming.

Gee practiced law in Columbus, Ohio, before joining the legal staff of Ohio Oil at Casper in 1950.

Peter T. Lamont and **Howard W. Page** have been elected to Standard Oil Company (New Jersey) board of directors.

Lamont has been associated with the Jersey Standard organization since 1922, except for a wartime leave of absence for service in the United States Navy. At present he is Jersey's coordinator of marketing activities. After graduation from MIT, in 1922, Lamont began his Jersey Standard career as a clerk in the sales department, after training as a student engineer in the company's oil fields and refineries.

Page, who has been with the Jersey organization for 24 years, has been Jersey's representative in the United Kingdom since 1949.

H. W. Jones, manager of industrial relations of The Atlantic Refining Company, has been elected a vice president of the company. He joined Atlantic in 1926 as a chemical engineer and was named manager of industrial relations in 1935. Jones was graduated from Massachusetts Institute of Technology in 1926 with a degree in chemical engineering.

G. Stewart Brown has been named chairman of the Oil Industry Information Committee for the coming year. He is public relations manager of Standard Oil of California, and succeeds Stanton K. Smith, Smith Oil and Refining Company president, as OIIC chairman.

E. M. Benson, Jr., district superintendent for Richfield Oil Corporation, has been named chairman and head of the program committee of the Los Angeles Chapter of API.

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Full-pressure lubrication keeps all major working parts correctly oiled. Thermostat controlled cooling maintains even running temperature. Large twin-disk clutch assures smooth power delivery to pumps.

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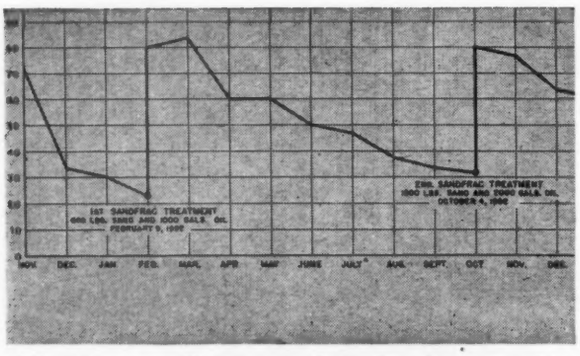
Economical Fracturing Treatment Developed by DOWELL Recommended for Sandstone, Conglomerate and Dolomitic Formations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600 LBS. SAND AND 1000 GALS. OIL
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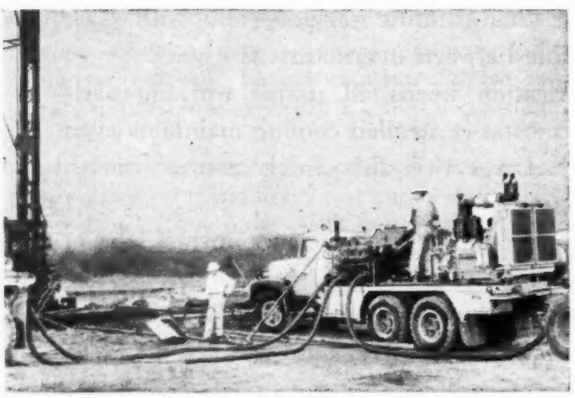
2ND. SANDFRAC TREATMENT
1000 LBS. SAND AND 1000 GALS. OIL
OCTOBER 4, 1952
NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

Old producers as well as new completions have been successfully fractured with Sandfrac. This chart illustrates its effectiveness. Note especially that both treatments resulted in greater production than when the well was first completed. Payout time was less than five days on the first job . . . less than six days on the second.



Dowell designs and builds its own pumping and mixing equipment to assure you the most effective Sandfrac service. Shown here is a late model diesel pump unit, constructed especially for use in well fracturing services.

Sandfrac* service is designed to increase oil production from both old and new wells. It has resulted in higher recovery rates and a boost in total recoverable reserves from hundreds of leases.

A Sandfrac treatment basically involves the displacing of oil and sand into a producing formation. And, after the fracturing oil returns to the well bore, the sand remains in the formation to act as a propping agent in existing and newly created fractures. Thus, the effective drainage area of the well is increased.

The sands used in Sandfrac treatments are carefully selected and are mixed in the oil, using specially designed mixing equipment. The grain size and the quantity of sand used can be varied to meet your specific well conditions. A recent trend in the use of sand, for example, calls for batch treatments—a fine-grained sand followed by a coarse-grained sand.** The fine sand helps to prepare the formation for the coarse one which follows. This method helps to eliminate sand screen-outs which can occur in treatment of some dense, tight pay zones.

The fracturing materials used to support and carry the sand are special, refined oils of medium gravity. These oils are carefully selected for their sand-suspension characteristics and pumpability. They may be resold by the operator following the treatment.

Sandfrac is economical, fast and requires no special well equipment or shut-in time.

Dowell engineers bring all materials, along with high-pressure pumping equipment, right to your well. They perform the job for you—their experience on thousands of these jobs benefits you.

Sandfrac is an adaptable service. It can be used both to complete and to retreat wells. It provides many advantages for the operator —each one designed for profitable results! It has been *proved in use* many times in a variety of formations. Why not look into this low-cost fracturing service? For full details on Sandfrac, call the Dowell station or office nearest you. Or, if you prefer, write directly to Tulsa, Department B-12.

*A Service mark of Dowell Incorporated
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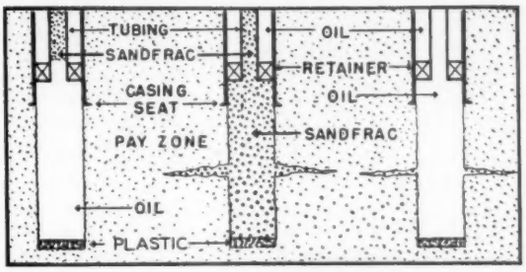

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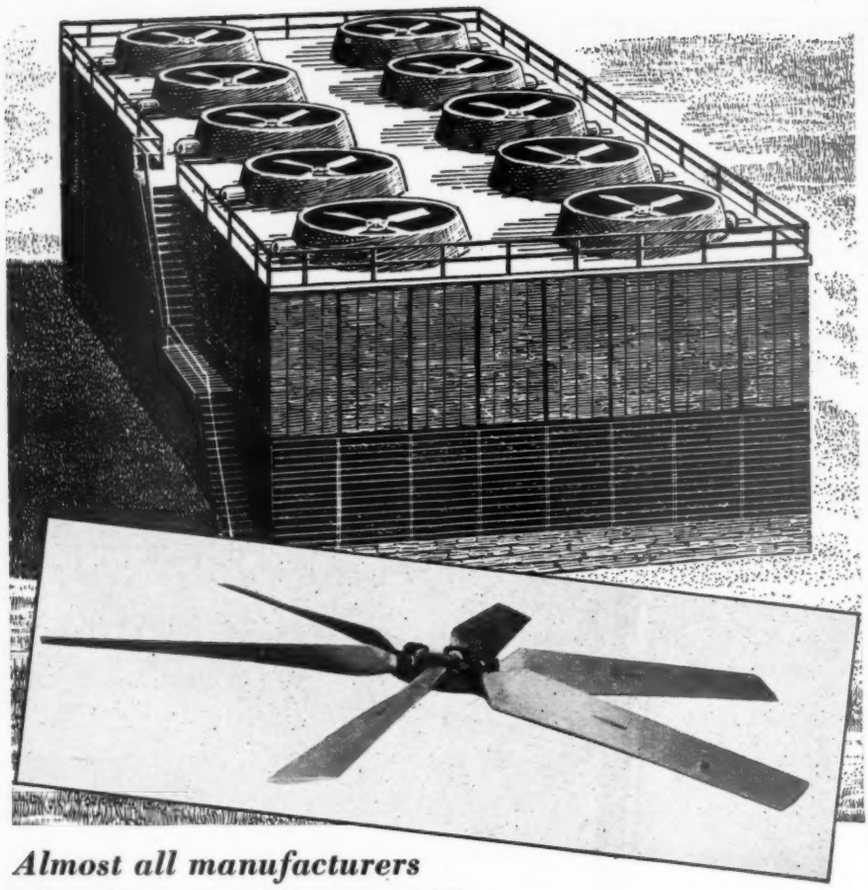

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Cooling towers, air coolers, cooling and condensing units—whatever your installation, Aeromaster Fans give you more cooling at lower cost! The reason is Aeromaster's unique two-way service.

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Name.....

Title.....Company.....

City.....Zone.....State.....

Personals

E. N. Redden has been named executive vice president of Five Star Oil Reports, succeeding Dr. Frank J. Gardner, who resigned to take a position with the Oil and Gas Journal, where he will head up the exploration-geological department.

Gardner had been president of Five Star since 1951. He was formerly associated with Rinehart Oil News. He will replace Philip C. Ingalls, who has resigned to join the geological staff of Socony-Vacuum Oil Company in New York.

A. H. Bransky has become senior patent attorney for Standard Oil Company (Indiana) in the general office in Chicago. In promotions made at the same time, **R. C. Arnold** and **R. B. Terry,** Chicago office technologists, were appointed patent advisors at Standard's Whiting, Indiana, laboratories.

B. A. Vance has been named technologist, replacing Dr. Arnold.

L. B. Stevens, Jr., has been transferred from the Whiting laboratories to Chicago as patent searcher, replacing Vance.

M. L. Kalinowski, project chemist, has been appointed patent advisor at the Whiting laboratories, replacing Stevens.

Robert A. Bishop of Sohio has been promoted to manager, Canada, replacing **Brame Womack,** who was transferred from Regina to Oklahoma City. Prior to his becoming manager of Canadian operations, Bishop was division geologist, Northwest division, Billings, Montana.

Bishop obtained his degree in geology from the University of Wisconsin, and did graduate work at Columbia University in New York City.

The post vacated by Bishop was taken by **Walter Johnson,** who was staff geologist, Northwest division, stationed in Lewistown, Montana.

Jack F. Gow has been appointed to the newly created post of manager of the public relations and publications department of the Eastern division of the Tide Water Associated Oil Company. Gow, a former newspaperman, has been with the company since 1946 beginning as employee publications editor and publicity representative at Bayonne, New Jersey.

W. A. Greeven, presently representative in Lisbon of the Standard Oil Company (New Jersey), with respect to the latter company's interests in Portugal, Spain and the North and Western African countries, will join Creole Petroleum Corporation in Caracas on April 1, 1954. Greeven brings to his new responsibilities an extensive background of oil experience gained in the period of more than twenty-five years of service which he has spent with many of Jersey's affiliates in Latin America and Europe.

A. E. (Al) Collins, well-known area purchasing and stores manager for Shell Oil Company, has retired after almost 42 years of service. Collins, with more years of service than any other Shell employee in the western half of the United States, began his long oil industry career in 1912 as a waterman in the Coalinga oil fields.

In addition to witnessing the early development of the Coalinga fields, he has served in Long Beach, San Francisco, and Los Angeles in various positions handling the company's purchasing activities.

Replacing Collins is **Rex C. Hensel** who was transferred from New York earlier this year. Hensel has filled managerial positions for the company in the Mid-Continent, Canadian, and New York.

Personals

Kempton H. Roll, Lead Industries Association, New York City has been elected chairman of North East Region, National Association of Corrosion Engineers. Also elected to serve during 1954 were **Edward G. Brink,** American Viscose Corporation, vice chairman, and **Edwin J. Titsworth,** Koppers, Company, Inc., secretary-treasurer.

George E. Best, Mutual Chemical Company, was elected to a three-year term on the NACE board of directors, effective with the last day of the 1954 NACE Conference at Kansas City. He succeeds **L. B. Donovan,** Consolidated Edison Company.

David E. Sleeper, certified public accountant, has opened offices as a tax consultant in the Tower Petroleum Building in Dallas. He will specialize in income and estate taxes especially as related to oil and geophysical matters.

For the last 10 years, Sleeper has been associated with National Geophysical Company of Dallas.

Dr. Herbert Insley, chief of the Mineral Products Division of the National Bureau of Standards, retired from NBS on December 31, 1953. He will remain in Washington after retirement and do consulting work.

Dr. Insley is internationally known for his researches in the microstructure and chemistry of mineral products. Before he became chief of the Bureau's Mineral Products Division in 1947, Dr. Insley was chief of the constitution and microstructure section and assistant chief of the mineral products division.

Harry A. Jackson has been appointed a vice president and chairman of the operating committee, Eastern division, Tide Water Associated Oil Company. Jackson will succeed **Drew L. Hines** whose request for retirement has been granted by the board of directors.

Jackson has been in the service of Tide Water for more than 30 years, commencing as a plant clerk in the sales department in California. Since 1947 Jackson has served as president of Seaside Oil Company, a California subsidiary of Tide Water.

Robert M. Chesney has been promoted to vice president, manufacturing, of Deep Rock Oil Corporation. The new vice president, formerly manager of the company's Cushing, Oklahoma, refinery will continue to live in that city.

In addition to overseeing refinery operations, he will assume new administrative responsibilities and will be in charge of Deep Rock's pipe line operations.

Operating headquarters of the pipe line department, with J. H. Tubbs as manager, will continue to be located in Tulsa.

Chesney has been associated with the oil industry in various capacities since 1934. He received a BS degree in chemical engineering from the University of Delaware in 1932 and did graduate work at Temple University.

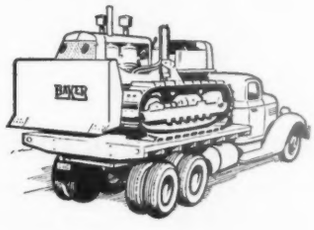
Harold P. Hobart, a vice president of Gulf Oil Corporation and various of its subsidiary companies, has retired. As vice president in charge of the company's domestic marketing department's product development and product engineering activities, Hobart has been concerned with the development and improvement of gasoline, fuel oil, lubricating oils, etc.; proper application of products, etc.

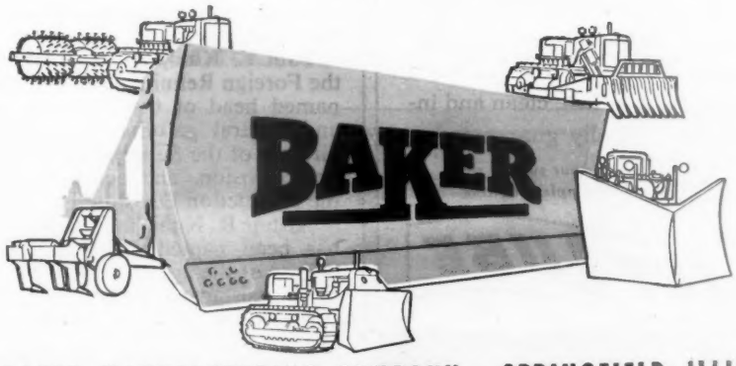
New Baker 15X—with 102 drawbar hp—combines peak yardage with portability

Proved on the famous 9X, Baker's revolutionary Frame-Mounted, No-Pushbeam Dozer design is already rolling up yardage records on the new, powerful 15X.

Here is a Blade 51" high but *only 96" wide* . . . portable over any highway, day *or* night, without special permits . . . that rolls up payloads with the capacity of a standard width blade. Here is a Blade mounted closer than ever before to the radiator—a simple, *rugged* design that reduces front end weight, and provides a center of gravity that puts more weight and horsepower to *work*. Engineered for *balance,* the Baker 15X Dozer permits drawbar work with the blade left *on* — without excess wear on front-end truck bearings.

See the powerful, new Baker 15X — see it in action, where you can watch its *faster* bite, *quicker* oscillation, and payload *punch* that means *more profits per yard. Ask your Baker, Allis-Chalmers Dealer for a demonstration!*





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ACTIVE YEAR is planned by the Pacific Petroleum Chapter of the American Institute of Mining and Metallurgical engineers at a meeting in Los Angeles recently. At that time M. E. Loy, Schlumberger Well Surveying, assumed the duties as chapter chairman, taking over from F. Lowry Wadsworth of General Petroleum. Present were: Sitting, Kemp Barley, Baroid Sales Division, councilor; Loy and Wadsworth; J. S. Bell, Humble, councilor. Standing are: R. S. Crog, California Research, 1953 chairman of petroleum technology committee; Phil C. Cook, Union Oil, chairman of membership directory committee; C. R. Dodson, of Stanley, Stolz, and Dodson, outgoing vice chairman; Hal Stanier, Sunray, councilor; Nick Van Wingen, consultant, 1953 senior past chairman; J. A. Klotz, California Research, secretary, and J. S. Baker, treasurer and councilor.

▸ **David H. West** of Red Bank, New Jersey, has been named assistant deputy administrator, Foreign Petroleum Operations, Petroleum Administration for Defense. West has held a number of positions within the agency since being named assistant director of the Foreign Supply and Transportation Division of PAD in January 1952. He was appointed director of that division in 1952.

Franz von Schilling, Jr., on leave from the California-Texas Oil Company, Ltd., has been named director of the Foreign Supply and Transportation Division of PAD. He previously had been assistant director of the division.

Philip M. Dean of Larchmont, New York, has been named assistant director of the Foreign Refining Division. He has been with PAD since 1952, as a special assistant in the Foreign Refining Division. He is on leave from the Standard Oil Company (New Jersey).

Announcement of the appointments in the Foreign Operations section follows an earlier announcement of two new assignments:

Paul E. Kuhl, formerly director of the Foreign Refining Division, has been named head of the domestic refining and natural gasoline division, acting director of the Supply and Transportation Division, and acting director of the Production Division.

Arthur R. Kuhl (no relation to Paul) has been named Public Information Officer of the agency. He formerly had been assistant director of the Public Information Division, working under Bryant Putney, who now has joined Socony-Vacuum Oil in New York.

▸ **Charles S. Jones,** president of the Richfield Oil Corporation, was elected president of the Western Oil and Gas Association, succeeding L. L. Aubert, president of Bankline Oil Company.

President of Richfield since its reorganization in 1917, Jones served as president of the association in 1934 and '35, while he was then president of Rio Grande Oil.

John W. Hancock, president of Hancock Oil, was elected first vice president; **Lowell Stanley,** chairman of the board, Monterey Oil, second vice president; and **William Reinhardt,** vice president of the Union Pacific Railroad, treasurer. **Felix Chappellet** was elected secretary and acting general manager.

Thirty incumbent members of the board were re-elected. Newly elected to the board were B. E. Devere, president of Pathfinder Petroleum and **R. R. Von Hagen,** president of Lloyd Corporation.

- CLASSIFIED -

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COMPLETE COMPRESSOR STATION

Two 600 H. P. Type L. V. G. Ingersoll-Rand gas engines with high pressure compressors. Engines and compressors complete including Parkersburg Building. Located twenty miles from Houston. Contact Petroleum Management Company, 565 San Jacinto Building, Houston, Texas. Phone: Charter 4781.

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AIRFIELD OR ROAD MATS
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Will be sold in any quantities
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DEATHS

Albert G. Lindsay, manager of Rockwell Manufacturing Company's export and international divisions, died in a New York City hospital December 4 after an illness of four months. Lindsay, former manager of Crosley Corporation's foreign division, joined Rockwell last April and made his headquarters at Pittsburgh.

A student of political economy, modern languages and law, he received his BA degree cum laude in 1919 from Humanistisches Gymnasium (a Swiss Federal College) at Basle, Switzerland, and his MA in 1922 from the Sorbonne.

Benjamin J. Harper, pioneer oil driller, died January 9. Harper drilled one of Texas' first major oil producers—famed Hayward No. 2 in the Spindletop field—and after leaving the oil fields his well contracting brought him to Dallas, Texas, where he had made his home.

Thomas W. Pew, president of General Crude Oil Company, died in Houston, Texas, January 4. Pew was the son of John G. Pew, retired president of Sun Oil Company, Pew's family has long been famous in oil and other industrial circles.

R. H. Hargrove, president of Texas Eastern Gas Transmission Corporation, died in a plane crash January 10. In the same plane with him were **John B. Atkins** and **J. P. Evans,** Shreveport, Louisiana, oil men. Twelve men in all lost their lives in the plane, which was carrying the group back to Shreveport from a duck hunting trip at Grand Chenier in Southern Louisiana.

Walter B. Templeton, founder and formerly chairman of the board of Templeton, Kenly and Company, manufacturers of Simplex mechanical and hydraulic jacks, died at Hinsdale, Illinois, December 6. Templeton formed the jack company in 1899 with the late W. K. Kenly. He served as president of the company for 40 years until 1939 when he was named chairman of the board.

Addison F. Holliday, former vice president and director of Plymouth and Big Lake Oil Companies and former president of Hiawatha Oil and Gas Company and Penn-Ohio Gas Company, died January 15 at his home in Pittsburgh. Holliday retired in 1952, closing a 61-year career that began with Senator William Flinn in 1891. He was associated with his uncle Addison B. Dally, Jr., in the Wheeling Natural Gas Company, organized by Senator Flinn. In 1922 the Senator's companies were taken over by famed wildcatter, M. L. Benedum, and from that date Holliday was associated with the Benedum interests.

In 1926 he was elected vice president and director of Hiawatha Oil and Gas Company and in October 1943 was elected president of that company, holding this position until August of 1946 when he resigned.

Howard A. Watson, Sun Oil Company field superintendent in the Gulf Coast area died recently in Beaumont, Texas.

Eben W. Pyle, a Kansas producer, died Christmas day in Kansas City following a heart attack. He made his home in Wichita.

John Patrick Keehan, assistant general accountant for Magnolia Petroleum Company died January 19. He had been a Magnolia employee for 28 years.

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- You just can't beat these small drop head dies for quick easy pipe or conduit threading.
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BOOKS ★

Synthesis of Hydrocarbons in the Gasoline Range. *Arranged by Dr. Cecil Boord, director, API Research Project No. 45. American Petroleum Institute, 50 West 50th Street, New York 20, New York. Price, $6.00. Pages, 261.*

This highly useful and fact-filled volume is a collection of reprints of scientific papers published on the above-mentioned project, along with six appendices presenting rleated phases of the work of the project, including advisory committe personnel, research staffs, list of papers serial bulletins, etc.

Hydrocarbons discussed in these eight chapters include olefins and di-olefins, ethers and alcohols, acetylenes and naphthenes and aromatics, along with seven papers presenting physical constants of a large number of hydrocarbons. Exhaustive discussions of the syntheses and properties of compounds are given in the various papers. For the researcher interested in comprehensive coverage of these materials this work is invaluable.

Hydrocarbons From Petroleum. *ACS Monograph No. 121, by Frederick D. Rossini, Beveridge J. Mair and Anton J. Streiff. Published by Reinhold Publishing Corporation, New York. Price, $18.50. Pages, 576.*

One of the major problems of the searcher for information on hydrocarbons has been the voluminousness of the various reports of results of work carried out on project No. 6 of the American Petroleum Institute on the "Fractionation, Analysis, Isolation, Purification and Properties of Petroleum Hydrocarbons." For any except the dyed-in-the-wool research chemist this mass of data has deterred the great majority from "digging in" to ferret out the information desired. Yet for a project of this fundamental type this voluminousness was and is all-important. It was indispensable that all the details of process and findings be given in exhaustive detail, for the information of all concerned, and no more monumental work has been carried out by man.

To aid the industry's people to be able to utilize these data to their advantage without too time-consuming search, and to boil down the relatively small compass—576 pages—these authors have prepared this volume of 27 chapters, that may be judged to run a higher percentage of fundamental facts per page than any volume published for the industry in many years. The first six chapters deal with various types of distillation procedures; then follows extraction, adsorption, and crystallization in three chapters. The remaining 18 chapters deal with hydrocarbon physical and chemical properties, composition, analytical methods as applied to the different fractions of petroleum. Altogether the volume is a MUST for the petroleum chemist of whatever phase of the industry he may be found. Detailed drawings of apparatus, mathematical derivations of many equations employed in the work, curves of product composition and an exhaustive subject index of the work reported make the book an excellent working guide as well as a standard reference work.

Trane Refrigeration Manual, *published by the Trane Company, La Crosse, Wisconsin. Price, $1.50. Pages, 125.*

The manual gives practical, easy-to-understand information on installation, operation, and servicing of refrigeration equipment for contractors and servicemen. Latest edition of the *Trane Refrigeration Manual* contains two entirely new chapters on refrigeration piping. This material embodies the latest engineering data on the subject. Other changes include a new chapter on refrigeration system control, a revised chapter on service operation and a completely revised refrigeration system service analysis chart.

Scientific Research and Development in American Industry—A Study of Manpower and Costs. *Issued by the U. S. Department of Labor, Washington 25, D. C. Available from U. S. Superintendent of Documents, U. S. Government Printing Office. Price, $0.50. Pages, 106.*

The bulletin is a comprehensive and detailed report on the Nation's industrial research resources. Nearly 2000 companies, with about 6,500,000 employees and sales totaling nearly $100 billion in 1951, were studied. Their scientific and engineering research programs cost almost $2 billion in 1951—about 85 per cent of the total national cost of industrial research and development.

Three manufacturing industries—aircraft, electrical machinery, and chemicals—do half of the industrial research and development work performed in this country, according to the report. These industries together employed more than 50,000 of the 96,000 research engineers and scientists covered by a 1952 study.

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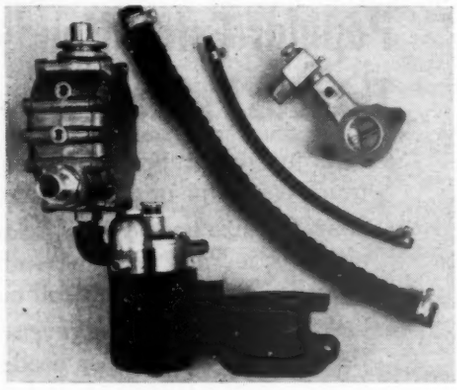

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SAFE LOADS FOR VARIOUS PARTS OF LINE

6 x 19 Classification Plow Steel

Uncoated Fiber Core Ropes

May also be used for 6 x 37 classification Plow Steel ropes.

Reduce safe load 8% for each additional idler or deflection sheave.

ROLLER BEARING SHEAVES—FACTOR OF SAFETY OF 5.

Safe Load in Tons of 2000 Pounds.

Rope diameter, inches	Number parts of line								
	2	3	4	5	6	7	8	9	10
1/4	.84	1.21	1.55	1.86	2.15	2.42	2.66	2.88	3.08
5/16	1.30	1.87	2.39	2.88	3.32	3.72	4.10	4.44	4.75
3/8	1.86	2.68	3.42	4.12	4.75	5.3	5.8	6.3	6.8
7/16	2.53	3.64	4.65	5.6	6.4	7.2	8.0	8.6	9.2
1/2	3.29	4.72	6.0	7.3	8.4	9.4	10.3	11.2	12.0
9/16	4.15	5.9	7.6	9.2	10.6	11.9	13.0	14.2	15.1
5/8	5.1	7.3	9.4	11.3	13.0	14.6	16.0	17.4	18.6
3/4	7.3	10.4	13.3	16.1	18.6	20.8	22.9	24.8	26.6
7/8	9.8	14.3	18.1	21.8	25.1	28.2	31.0	33.6	36.0
1	12.8	18.4	23.6	28.4	32.8	36.8	40.4	43.8	46.8
1 1/8	16.0	23.0	29.4	35.4	40.7	45.8	50.3	54.5	58.0
1 1/4	19.7	28.3	36.2	43.5	50.2	56.3	62.0	67.0	72.0
1 3/8	23.7	34.2	43.6	52.0	60.5	68.0	75.0	81.0	86.7
1 1/2	28.1	40.5	52.0	62.0	72.0	80.5	88.3	96.0	103.0

Example—If it is desired to hoist a load of 12 tons with a 5/8" diameter 6 x 19 classification Plow Steel rope, it will be determined from the above table that it will be necessary to string 6 lines, using blocks with plain bearing sheaves.

SAFE LOADS FOR VARIOUS PARTS OF LINE

6 x 19 Classification Plow Steel

Uncoated Fiber Core Ropes

May also be used for 6 x 37 classification Plow Steel ropes.

Reduce safe load 8% for each additional idler or deflection sheave.

PLAIN BEARING SHEAVES—FACTOR OF SAFETY OF 5.

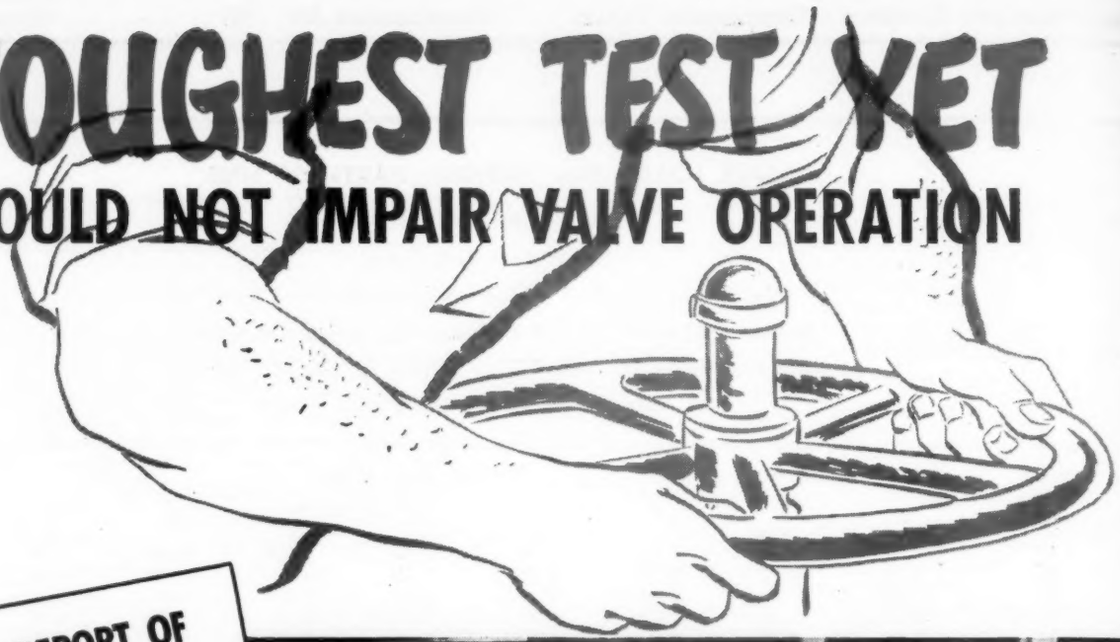
Safe Load in Tons of 2000 Pounds.

Rope diameter, inches	Number parts of line								
	2	3	4	5	6	7	8	9	10
1/4	.97	1.39	1.78	2.14	2.47	2.77	3.05	3.30	3.54
5/16	1.49	2.15	2.76	3.30	3.81	4.28	4.70	5.1	5.4
3/8	2.14	3.08	3.95	4.75	5.5	6.1	6.7	7.3	7.8
7/16	2.90	4.18	5.3	6.4	7.4	8.3	9.1	9.9	10.6
1/2	3.75	5.4	6.9	8.3	9.6	10.8	11.8	12.8	13.7
9/16	4.75	6.8	8.8	10.5	12.1	13.6	14.9	16.2	17.3
5/8	5.9	8.4	10.8	13.0	14.9	16.8	18.5	20.0	21.4
3/4	8.4	12.0	15.4	18.5	21.3	24.0	26.4	28.6	30.5
7/8	11.3	16.3	20.8	25.0	28.8	32.4	35.6	38.6	41.3
1	14.7	21.2	27.2	32.6	37.6	42.2	46.5	50.3	54.0
1 1/8	18.5	26.6	34.0	40.8	47.0	52.8	58.1	63.0	67.4
1 1/4	22.6	32.6	41.8	50.2	57.8	65.0	71.4	77.3	82.8
1 3/8	27.2	39.2	50.1	60.3	69.5	78.0	85.8	92.9	99.5
1 1/2	32.3	46.5	59.5	71.6	82.5	92.6	102.0	110.0	118.0

Example—If it is desired to hoist a load of 12 tons with a 5/8" diameter 6 x 19 classification Improved Plow Steel rope, it will be determined from the above table that it will be necessary to string 5 lines, using blocks with plain bearing sheaves.

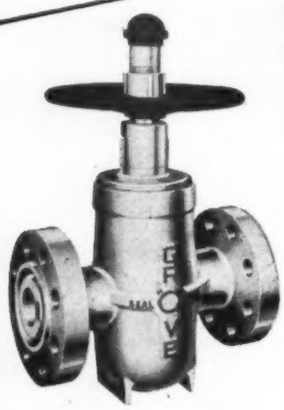
Courtesy of Wickwire Rope, The Colorado Fuel and Iron Corporation

TOUGHEST TEST YET
COULD NOT IMPAIR VALVE OPERATION



A FULL REPORT OF ACCELERATED LIFE TESTS WILL BE FURNISHED

—by major gas transmission and producing company conducting this test



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Just imagine loading the conduit of a 6" valve, swabbed with an excess of motor oil, *first*, with several shovels full of sand and rock from pea size to ¾" irregular shapes. The valve was forced through the debris into closed position. When 695 psig line pressure was turned into the valve, absolute seal was effected. Then, the valve was opened and the trapped volume of gas, rocks and sand was released to atmosphere. *Next*, the conduit was loaded with welding slag and sharp pieces of pipe metal cut by a torch, and again the valve was closed and pressure applied. After a period of throttling, the valve was bled to atmosphere, clearing out the slag and scrap metal. *Finally*, the valve was again closed and held *absolutely bubble tight*. Final inspection showed no damage that would impair continued service, or prevent smooth, effortless operation.

For complete test data, write for name of major gas company.

S-308

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GROVE REGULATOR COMPANY • 65th & Hollis Sts., Oakland 8, California

HOUSTON 4—1901 Calumet St. • **LOS ANGELES 14**—649 So. Olive St. • **NEW YORK 17**—415 Lexington Ave.

GROVE SIMPLICITY ACCURACY SAFETY

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SAFE LOADS FOR VARIOUS PARTS OF LINE

6 x 19 Classification Plow Steel

Uncoated Fiber Core Ropes

May also be used for 6 x 37 classification Plow Steel ropes.

Reduce safe load 4% for each additional idler or deflection sheave.

PLAIN BEARING SHEAVES—FACTOR OF SAFETY OF 5.

Safe Load in Tons of 2000 Pounds.

Rope diameter, inches	Number parts of line								
	2	3	4	5	6	7	8	9	10
1/4	.90	1.32	1.73	2.13	2.52	2.88	3.23	3.56	3.88
5/16	1.39	2.04	2.67	3.28	3.88	4.43	4.97	5.5	6.0
3/8	1.99	2.92	3.83	4.71	5.5	6.3	7.1	7.8	8.5
7/16	2.70	3.95	5.2	6.4	7.5	8.6	9.6	10.6	11.6
1/2	3.50	5.15	6.7	8.3	9.8	11.2	12.5	13.9	15.1
9/16	4.42	6.5	8.5	10.5	12.3	14.1	15.8	17.5	19.1
5/8	5.4	8.0	10.4	12.9	15.2	17.4	19.5	21.5	23.4
3/4	7.7	11.4	14.9	18.4	21.7	24.8	27.8	30.7	33.5
7/8	10.5	15.4	20.2	24.9	29.3	33.5	37.6	41.5	45.4
1	13.7	20.1	26.3	32.4	38.2	43.7	49.1	54.2	59.1
1 1/8	17.0	25.0	32.9	40.4	47.7	54.5	61.2	67.5	73.7
1 1/4	21.0	30.8	40.4	49.7	58.7	67.1	75.3	83.1	90.7
1 3/8	25.2	37.2	48.8	60.0	70.8	80.9	90.8	100.0	109.0
1 1/2	30.0	44.1	57.8	71.1	83.9	95.9	108.0	119.0	130.0

Example—If it is desired to hoist a load of 12 tons with a 5/8" diameter 6 x 19 classification Plow Steel rope, it will be determined from the above table that it will be necessary to string 5 lines, using blocks with roller bearing sheaves.

SAFE LOADS FOR VARIOUS PARTS OF LINE

6 x 19 Classification Improved Plow Steel

Uncoated Fiber Core Ropes

May also be used for 6 x 37 classification Plow Steel ropes.

Reduce safe load 4% for each additional idler or deflection sheave.

ROLLER BEARING SHEAVES—FACTOR OF SAFETY OF 5.

Safe Load in Tons of 2000 Pounds.

Rope diameter, inches	Number parts of line								
	2	3	4	5	6	7	8	9	10
1/4	1.03	1.51	1.98	2.44	2.88	3.30	3.70	4.08	4.45
5/16	1.59	2.34	3.07	3.78	4.45	5.1	5.7	6.3	6.9
3/8	2.28	3.36	4.41	5.4	6.4	7.3	8.2	9.0	9.9
7/16	3.09	4.55	5.96	7.3	8.6	9.9	11.1	12.2	13.3
1/2	4.01	5.89	7.7	9.5	11.2	12.8	14.4	15.9	17.3
9/16	5.05	7.4	9.7	12.0	14.1	16.2	18.2	20.0	21.8
5/8	6.2	9.2	12.0	14.8	17.5	20.0	22.5	24.8	27.0
3/4	8.9	13.1	17.2	21.2	25.0	28.5	32.0	35.3	38.5
7/8	12.0	17.7	23.2	28.6	33.8	38.6	43.3	47.8	52.1
1	15.7	23.1	30.3	37.3	44.0	50.0	56.5	62.3	68.0
1 1/8	19.7	28.9	37.9	46.6	55.0	63.0	70.6	78.0	85.0
1 1/4	24.1	35.5	46.6	57.3	67.6	77.0	86.7	.96.0	105.0
1 3/8	29.0	42.7	56.0	68.8	81.2	93.0	104.0	115.0	126.0
1 1/2	34.4	50.7	66.5	81.7	96.4	110.0	124.0	137.0	149.0

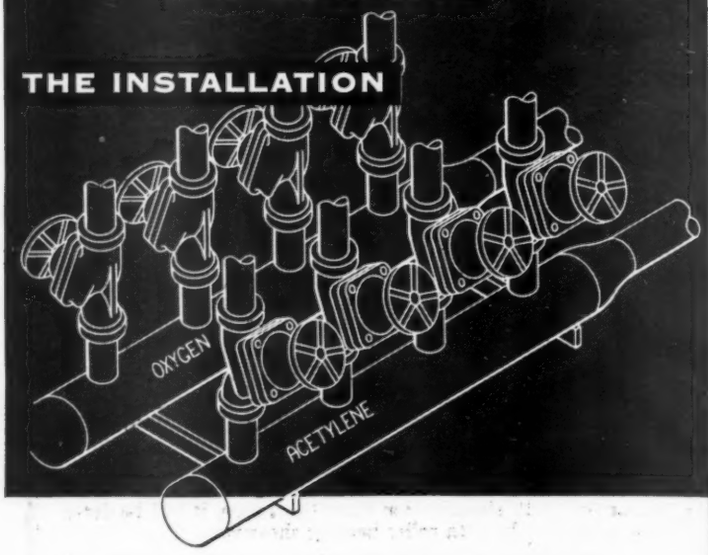
Example—If it is desired to hoist a load of 12 tons with a 5/8" diameter 6 x 19 classification Improved Plow Steel rope, it will be determined from the above table that it will be necessary to string 4 lines, using blocks with roller bearing sheaves.

Courtesy of Wickwire Rope, The Colorado Fuel and Iron Corporation

This Valve Stops Hidden Losses

...in Welding Gas Systems, for instance

THE INSTALLATION



In a prominent New Orleans shipyard, with Crane Diaphragm valves listed as "standard operating procedure" for complete oxygen-acetylene system. Shown is typical installation on portable manifold.

VALVE SERVICE RATINGS

SUITABILITY:
100% effective – no leakage

FEATURES:
No seating stress on diaphragm

MAINTENANCE COST:
Zero

SERVICE LIFE:
Installed 2 yrs – long life indicated

OPERATING RESULT:
Big savings on welding gas costs

AVAILABILITY:
Crane Catalog item – No. 1652

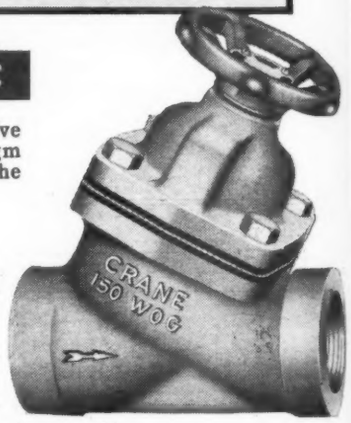
THE CASE HISTORY

Costly loss of welding gases was traced to the conventional packed valves formerly used on the system. Leakage through the stuffing persisted despite frequent, regular servicing of stem packing on the valves. This high maintenance cost added to the yard's loss.

The remedy was found in Crane No. 1652 packless Diaphragm Valves, Underwriters approved for the service. These valves stopped the leakage, and not one Crane valve has needed attention since installed more than 2 years ago. Despite continued expansion, the yard's costs for welding gas have been sharply reduced.

THE VALVE

The modern packless valve with Neoprene diaphragm that serves only to seal the bonnet. Its independent disc saves diaphragm wear, provides positive seating on fluid, even should the diaphragm fail. Choose from a wide range of body and trim materials for all kinds of corrosive and ordinary services. Sizes ½ to 6 in.; screwed or flanged ends. See your Crane Catalog, or your Crane Representative.



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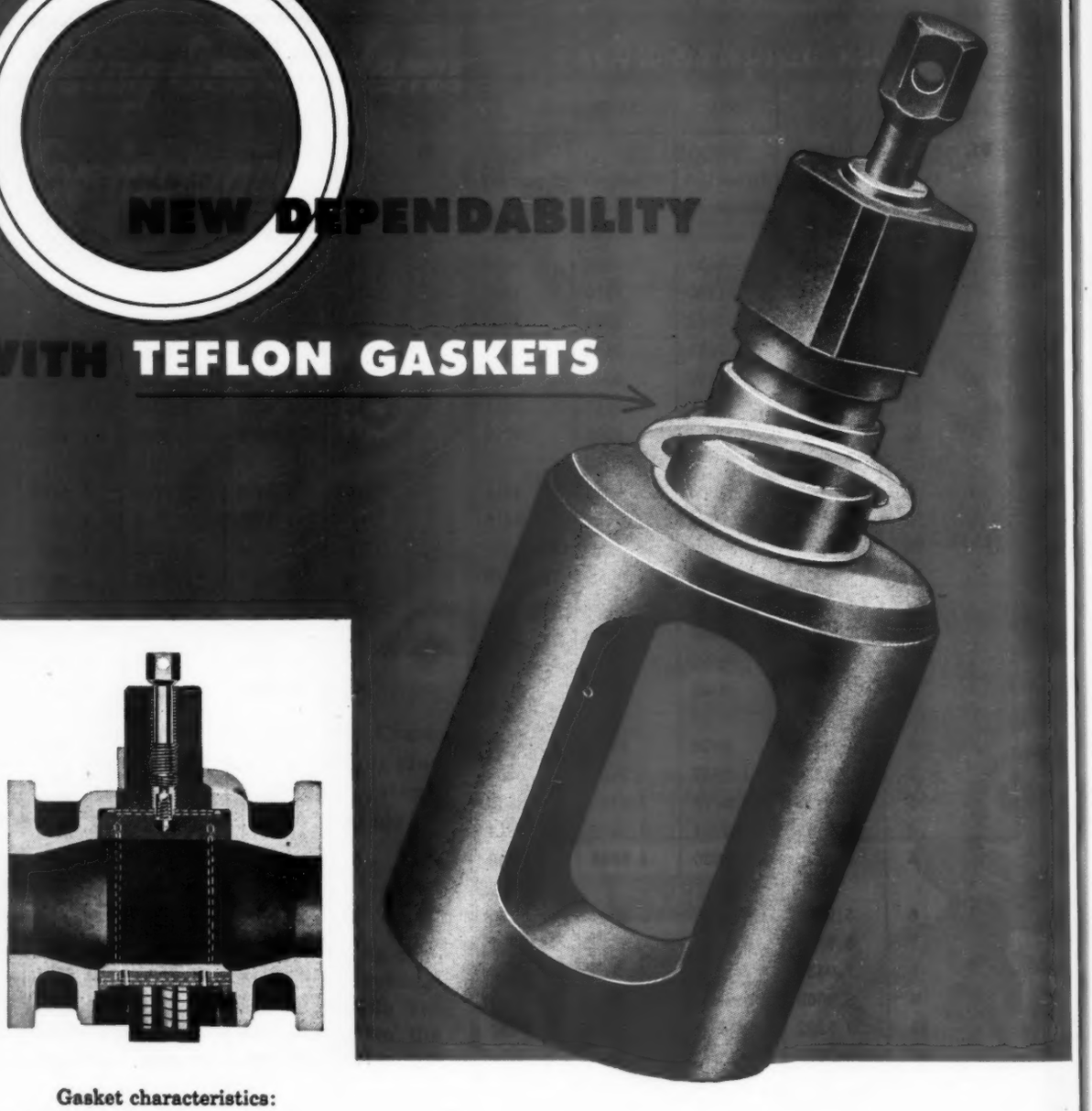
100 and 200 bbl. A. P. I. tanks						250 and high 500 bbl. A. P. I. tanks					
Ft.	In.	Gross	Net: Gross less deadwood	Net less: 2 percent	Net less: 3 percent	Ft.	In.	Gross	Net: Gross less deadwood	Net less: 2 percent	Net less: 3 percent
	1/16	.0621	.0620	.0608	.0602		1/16	.1725	.1724	.1690	.1672
	1/8	.1241	.1240	.1216	.1204		1/8	.3449	.3448	.3379	.3345
	3/16	.1862	.1861	.1824	.1805		3/16	.5174	.5173	.5070	.5017
	1/4	.2482	.2481	.2432	.2407		1/4	.6898	.6897	.6759	.6690
	5/16	.3103	.3102	.3040	.3009		5/16	.8623	.8621	.8449	.8362
	3/8	.3723	.3722	.3648	.3611		3/8	1.0348	1.0345	1.0138	1.0035
	7/16	.4344	.4343	.4256	.4212		7/16	1.2072	1.2069	1.1828	1.1707
	1/2	.4965	.4963	.4864	.4814		1/2	1.3797	1.3794	1.3518	1.3380
	9/16	.5585	.5583	.5472	.5416		9/16	1.5521	1.5518	1.5208	1.5052
	5/8	.6206	.6204	.6080	.6018		5/8	1.7246	1.7242	1.6897	1.6725
	11/16	.6826	.6824	.6688	.6619		11/16	1.8971	1.8966	1.8587	1.8397
	3/4	.7447	.7445	.7296	.7221		3/4	2.0695	2.0690	2.0276	2.0069
	13/16	.8068	.8065	.7904	.7823		13/16	2.2420	2.2415	2.1967	2.1743
	7/8	.8688	.8685	.8512	.8425		7/8	2.4144	2.4139	2.3656	2.3415
	15/16	.9309	.9306	.9120	.9027		15/16	2.5869	2.5863	2.5346	2.5087
	1	.9929	.9926	.9728	.9628		1	2.7594	2.7587	2.7035	2.6759
	2	1.9858	1.9852	1.9455	1.9257		2	5.5187	5.5174	5.4071	5.3519
	3	2.9788	2.9778	2.9183	2.8885		3	8.2781	8.2762	8.1107	8.0279
	4	3.9717	3.9704	3.8910	3.8513		4	11.0374	11.0349	10.8142	10.7039
	5	4.9646	4.9630	4.8638	4.8142		5	13.7968	13.7936	13.5177	13.3798
	6	5.9575	5.9556	5.8365	5.7770		6	16.5562	16.5523	16.2213	16.0557
	7	6.9505	6.9483	6.8093	6.7398		7	19.3155	19.3111	18.9249	18.7318
	8	7.9434	7.9409	7.7820	7.7026		8	22.0749	22.0698	21.6284	21.4077
	9	8.9363	8.9335	8.7548	8.6655		9	24.8343	24.8285	24.3319	24.0836
	10	9.9292	9.9261	9.7276	9.6283		10	27.5936	27.5872	27.0355	26.7596
	11	10.9222	10.9187	10.7003	10.5911		11	30.3530	30.3459	29.7390	29.4355
1		11.9151	11.9113	11.6731	11.5540	1		33.1123	33.1047	32.4426	32.1116
2		23.8302	23.8226	23.3461	23.1079	2		66.2247	66.2093	64.8851	64.2230
3		35.7453	35.3339	35.0192	34.6619	3		99.3370	99.3140	97.3277	96.3346
4		47.6604	45.6452	46.6923	46.2158	4		132.4494	132.4187	129.7703	128.4461
5		59.5754	59.5565	58.3654	57.7698	5		165.5617	165.5234	162.2129	160.5577
6		71.4905	71.4678	70.0384	69.3238	6		198.6740	198.6280	194.6554	192.6692
7		83.4056	83.3791	81.7115	80.8777	7		231.7864	231.7327	227.0980	224.7807
8		95.3207	95.2904	93.3846	92.4317	8		264.8987	264.8374	259.5407	256.8923
9		107.2358	107.2017	105.0577	103.9856	9		298.0110	297.9421	291.9833	289.0038
10		119.1509	119.1180	116.7307	115.5896	10		331.1234	331.0467	324.4258	321.1153
11		131.0660	131.0243	128.4038	127.0936	11		364.2357	364.1514	356.8684	353.2269
12		142.9811	142.9356	140.0769	138.6475	12		397.3481	397.2561	389.3110	385.3384
13		154.8962	154.8469	151.7500	150.2015	13		430.4604	430.3607	421.7535	417.4499
14		166.8113	166.7582	163.4230	161.7554	14		463.5727	463.4654	454.1961	449.5614
15		178.7263	178.6695	175.0961	173.3094	15		496.6851	496.5701	486.6387	481.6730
16		190.6414	190.5808	186.7692	184.8634	16		529.7974	529.6748	519.0813	513.7846

NEW DEPENDABILITY

WITH TEFLON GASKETS



Gasket characteristics:

- self lubricating
- can't bind
- unique shape maintains lubricant release
- pressure tight

Round Port Valves—100% Obstruction Free • Rectangular Port Valves with Full Pipe Area • Venturi Valves for Economy

Now standard on a.c.f. Lubricated Plug Valves, this exclusive a.c.f. development gives protection against head leakage at high pressure and at temperatures up to 450° F. Greatly reduces turning torque. Increases service life without materially affecting price.

Four years of field service tests under most exacting conditions have confirmed the effectiveness of this new discovery. Get all the facts from your nearby a.c.f. valve representative.

a.c.f. Representatives in 50 Principal Cities

CYLINDRICAL FULL PIPE AREA

PLUG VALVES

Write for Catalog No. 4-P.E. and Price List. American Car and Foundry Company, Valve Division, 1501 E. Ferry Avenue, Detroit 11, Michigan.

CAPACITY OF BOLTED STEEL TANKS, 42-GAL. BBL.

Low 500 and high 1,000 A. P. I. tanks

Ft.	In.	Gross	Net	Net less	
			Gross less deadwood	2 percent	3 percent
	1/16	.3381	.3380	.3312	.3279
	1/8	.6762	.6760	.6625	.6557
	3/16	1.0143	1.0140	.9937	.9836
	1/4	1.3524	1.3520	1.3250	1.3114
	5/16	1.6904	1.6900	1.6562	1.6393
	3/8	2.0285	2.0280	1.9874	1.9672
	7/16	2.3666	2.3659	2.3186	2.2949
	1/2	2.7047	2.7039	2.6498	2.6228
	9/16	3.0428	3.0419	2.9811	2.9506
	5/8	3.3809	3.3799	3.3123	3.2785
	11/16	3.7190	3.7179	3.6435	3.6064
	3/4	4.0571	4.0559	3.9748	3.9342
	13/16	4.3951	4.3939	4.3060	4.2621
	7/8	4.7332	4.7319	4.6373	4.5899
	15/16	5.0713	5.0699	4.9685	4.9178
	1	5.4094	5.4079	5.2997	5.2457
	2	10.8188	10.8158	10.5995	10.4913
	3	16.2282	16.2237	15.8992	15.7370
	4	21.6376	21.6315	21.1989	20.9826
	5	27.0470	27.0394	26.4986	26.2282
	6	32.4564	32.4473	31.7984	31.4739
	7	37.8659	37.8552	37.0981	36.7195
	8	43.2753	43.2631	42.3978	41.9652
	9	48.6847	48.6710	47.6976	47.2109
	10	54.0941	54.0788	52.9972	52.4564
	11	59.5035	59.4867	58.2970	57.7021
1		64.9129	64.8946	63.5967	62.9478
2		129.8258	129.7892	127.1934	125.8955
3		194.7387	194.6838	190.7901	188.8433
4		259.6516	259.5784	254.3868	251.7910
5		324.5645	324.4730	317.9835	314.7388
6		389.4774	389.3676	381.5802	377.6866
7		454.3903	454.2623	445.1771	440.6344
8		519.3032	519.1569	508.7738	503.5822
9		584.2161	584.0515	572.3705	566.5300
10		649.1290	648.9461	635.9672	629.4777
11		714.0419	713.8407	699.5639	692.4255
12		778.9548	778.7353	763.1606	755.3732
13		843.8676	843.6299	826.7573	818.3210
14		908.7805	908.5245	890.3540	881.2688
15		973.6934	973.4191	953.9507	944.2165
16		1038.6063	1038.3137	1017.5474	1007.1643

Low 1,000 and 2,000 bbl. A. P. I. tanks

Ft.	In.	Gross	Net	Net less	
			Gross less deadwood	2 percent	3 percent
	1/16	.6435	.6433	.6304	.6240
	1/8	1.2870	1.2866	1.2608	1.2480
	3/16	1.9304	1.9299	1.8913	1.8720
	1/4	2.5739	2.5732	2.5217	2.4960
	5/16	3.2174	3.2164	3.1521	3.1199
	3/8	3.8609	3.8597	3.7825	3.7439
	7/16	4.5043	4.5030	4.4130	4.3679
	1/2	5.1478	5.1463	5.0434	4.9919
	9/16	5.7913	5.7896	5.6738	5.6159
	5/8	6.4348	6.4329	6.3042	6.2399
	11/16	7.0783	7.0762	6.9346	6.8639
	3/4	7.7217	7.7195	7.5651	7.4879
	13/16	8.3652	8.3627	8.1955	8.1119
	7/8	9.0087	0.0060	8.8259	8.7359
	15/16	9.6522	9.6493	9.4563	9.3598
	1	10.2956	10.2926	10.0868	9.9838
	2	20.5913	20.5852	20.1735	19.9677
	3	30.8869	30.8778	30.2603	29.9515
	4	41.1825	41.1704	40.3470	39.9353
	5	51.4782	51.4630	50.4338	49.9192
	6	61.7738	61.7557	60.5205	59.9030
	7	72.0695	72 0483	70.6073	69.8868
	8	82.3651	82.3409	80.6941	79.8706
	9	92.6607	92.6335	90.7808	89.8545
	10	102.9564	102.9261	100.8676	99.8383
	11	113.2520	113.2187	110.9543	109.8221
1		123.5476	123.5113	121.0411	119.8060
2		247.0953	247.0226	242.0822	239.6119
3		370 6429	370.5339	363.1232	359.4179
4		494.1906	494.0452	484.1643	479.2239
5		617.7382	617.5565	605.2054	599.0298
6		741.2858	741.0678	726.2465	718.8358
7		864 8335	864.5791	847.2875	838.6418
8		988.3811	988.0904	968.3286	958 4477
9		1111.9288	1111.6017	1089.3697	1078 2537
10		1235.4764	1235.1130	1210.4108	1198 0597
11		1359.0240	1358.6243	1331.4519	1317.8656
12		1482.5717	1482 1357	1452.4929	1437 6716
13		1606 1193	1605.6470	1573.5340	1557.4775
14		1729 6670	1729 1583	1694.5751	1677.2835
15		1853.2146	1852.6696	1815.6162	1797.0895
16		1976.7622	1976.1809	1936.6572	1916.8954

Let's talk SENSE about PLASTIC PIPE

• Let's face it! Plastic pipe is revolutionizing oil country piping. Of course plastic cannot be used on every installation . . . but even metallic piping is impractical for certain applications.

• CARLON Plastic Pipe is specifically developed for oil country piping and has been rigidly tested. Carlon engineers have determined exactly how CARLON Plastic Pipe will perform on specific installations.

• CARLON is definitely superior to metal pipe when used for lead, distribution, salt water disposal and gathering lines, as well as risers, gas vents and fresh water transmission.

• CARLON resists the effects of acids, crude oil, sour crude and sulphurous waters. The smooth interior walls in most instances prevent accumulation of paraffin, scale and sediment and remain clean throughout the installation period.

• CARLON is not a universal oil piping material . . . it has limitations. But if utilized within the established limits of pressure and temperature, CARLON Plastic Pipe provides years of trouble-free service. Use it right and you can't go wrong . . . that's why CARLON is unconditionally guaranteed to meet the highest standards of quality and performance.

Send today for complete information on CARLON Plastic Pipe for oil country piping.

CARLON

THE PIPE WITH THE STRIPE

CARLON PRODUCTS CORPORATION

Pioneers in Plastic Pipe

10555 MEECH AVENUE • CLEVELAND 5, OHIO

THE FIRST REAL PIPE THAT IS PLASTIC • BUY THE PIPE WITH THE STRIPE!

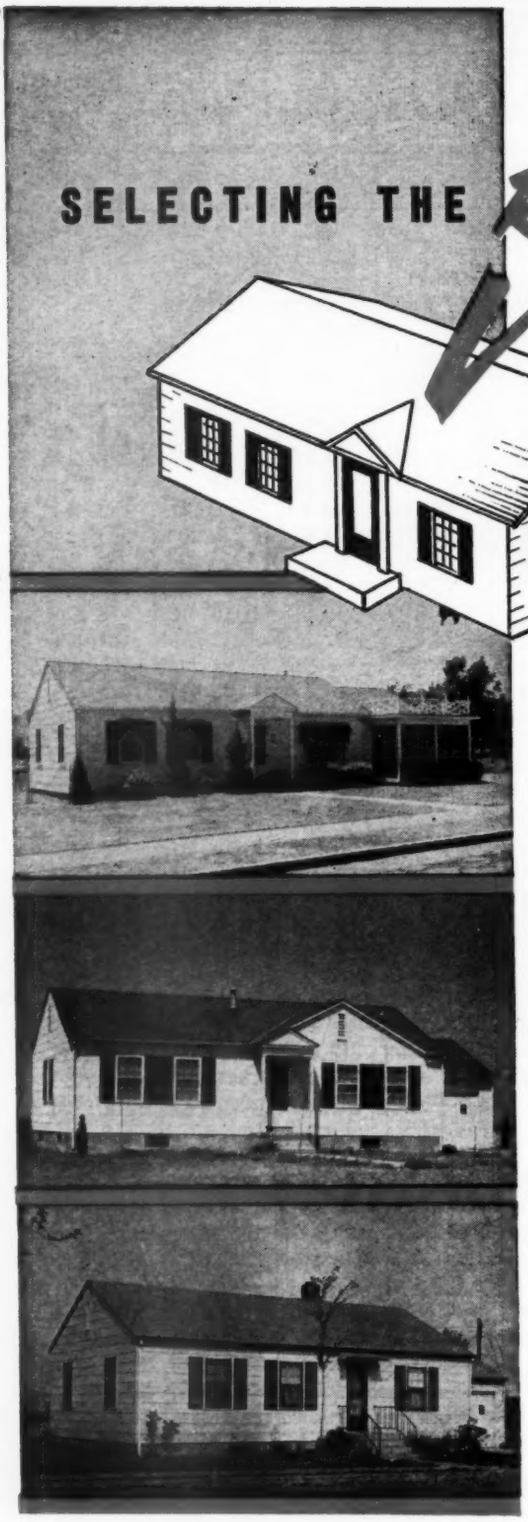
1718-UP

CARLON PLASTIC PIPE IS PRODUCED IN TEXAS, COLORADO, OHIO, OREGON, NORTH CAROLINA AND ONTARIO

CAPACITY OF BOLTED STEEL TANKS, 42-GAL. BBL.

5,000 bbl. A. P. I. tank						10,000 bbl. A P. I. tank					
Ft.	In.	Gross	Net	Net less		Ft.	In.	Gross	Net	Net less	
			Gross less deadwood	2 percent	3 percent				Gross less deadwood	2 percent	3 percent
	1/16	1.0875	1.0872	1.0655	1.0546		1/16	2.2023	2.2017	2.1577	2.1356
	1/8	2.1751	2.1745	2.1310	2.1093		1/8	4.4045	4.4034	4.3153	4.2713
	3/16	3.2626	3.2617	3.1965	3.1639		3/16	6.6068	6.6051	6.4730	6.4069
	1/4	4.3501	4.3490	4.2620	4.2185		1/4	8.8090	8.8067	8.6306	8.5425
	5/16	5.4377	5.4362	5.3275	5.2731		5/16	11.0113	11.0084	10.7883	10.6782
	3/8	6.5252	6.5235	6.3930	6.3278		3/8	13.2135	13.2101	12.9459	12.8138
	7/16	7.6127	7.6107	7.4585	7.3824		7/16	15.4158	15.4118	15.1036	14.9495
	1/2	8.7003	8.6980	8.5240	8.4370		1/2	17.6180	17.6135	17.2612	17.0851
	9/16	9.7878	9.7852	9.5895	9.4917		9/16	19.8203	19.8152	19.4189	19.2207
	5/8	10.8753	10.8725	10.6550	10.5463		5/8	22.0225	22.0169	21.5765	21.3564
	11/16	11.9629	11.9597	11.7205	11.6009		11/16	24.2248	24.2186	23.7342	23.4920
	3/4	13.0504	13.0470	12.7860	12.6555		3/4	26.4270	26.4202	25.8918	25.6276
	13/16	14.1379	14.1342	13.8515	13.7102		13/16	28.6293	28.6219	28.0495	27.7633
	7/8	15.2255	15.2215	14.9170	14.7648		7/8	30.8316	30.8236	30.2071	29.8989
	15/16	16.3130	16.3087	15.9825	15.8194		15/16	33.0338	33.0253	32.3648	32.0345
	1	17.4005	17.3959	17.0480	16.8741		1	35.2361	35.2270	34.5225	34.1702
	2	34.8010	34.7919	34.0960	33.7481		2	70.4721	70.4540	69.0449	68.3404
	3	52.2016	52.1878	51.1440	50.6222		3	105.7082	105.6810	103.5674	102.5106
	4	69.6021	69.5838	68.1920	67.4963		4	140.9443	140.9080	138.0898	136.6807
	5	87.0026	86.9797	85.2400	84.3703		5	176.1803	176.1350	172.6123	170.8509
	6	104.4031	104.3757	102.2880	101.2444		6	211.4164	211.3620	207.1347	205.0211
	7	121.8036	121.7716	119.3360	118.1185		7	246.6525	246.5890	241.6572	239.1913
	8	139.2042	139.1675	136.3840	134.9925		8	281.8885	281.8160	276.1796	273.3615
	9	156.6047	156.5635	153.4320	151.8666		9	317.1246	317.0430	310.7021	307.5317
	10	174.0052	173.9594	170.4800	168.7407		10	352.3607	352.2700	345.2246	341.7019
	11	191.4057	191.3554	187.5280	185.6147		11	387.5967	387.4970	379.7470	375.8720
1		208.8062	208.7513	204.5763	202.4888	1		422.8328	422.7239	414.2695	410.0422
2		417.6125	417.5027	409.1526	404.9776	2		845.6656	845.4479	828.5389	820.0845
3		626.4187	626.2540	613.7289	607.4663	3		1268.4984	1268.1718	1242.8084	1230.1267
4		835.2249	835.0053	818.3052	809.9551	4		1691.3311	1690.8958	1657.0779	1640.1689
5		1044.0312	1043.7566	1022.8815	1012.4489	5		2114.1639	2113.6197	2071.3474	2050.2111
6		1252.8374	1252.5080	1227.4578	1214.9327	6		2536.9967	2536.3437	2485.6168	2460.2534
7		1461.6437	1461.2593	1432.0341	1417.4215	7		2959.8295	2959.0676	2899.8863	2870.2956
8		1670.4499	1670.0106	1636 6104	1619.9103	8		3382.6623	3381.7916	3314.1558	3280.3378
9		1879.2561	1878.7619	1841.1867	1822.3990	9		3805.4951	3804.5155	3728.4252	3690.3801
10		2088.0624	2087.5133	2045.7630	2024.8878	10		4228.3278	4227.2395	4142.6947	4100.4223
11		2296.8686	2296.2646	2250.3393	2227.3766	11		4651.1606	4649.9634	4556.9642	4510.4645
12		2505.6748	2505.0159	2454.9156	2429.8654	12		5073.9934	5072.6874	4971.2337	4920.5068
13		2714.4811	2713.7672	2659.4919	2632.3542	13		5496.8262	5495.4113	5385.5031	5330.5490
14		2923.2873	2922.5186	2864.0682	2834.8430	14		5919.6590	5918.1353	5799.7726	5740.5912
15		3132.0936	3131.2699	3068.6445	3037.3317	15		6342.4918	6340.8592	6214.0421	6150.6334
16		3340.8998	3340.0212	3273.2208	3239.8205	16		6765.3246	6763.5832	6628.3115	6560.6757
17		3549.7060	3548.7725	3477.7971	3442.3093	17		7188.1573	7186.3071	7042.5810	6970.7179
18		3758.5123	3757.5239	3682.3734	3644.7981	18		7610.9901	7609.0311	7456.8505	7380.7601
19		3967.3185	3966.2752	3886.9497	3847.2869	19		8033.8229	8031.7550	7871.1199	7790.8024
20		4176.1247	4175.0265	4091.5260	4049.7757	20		8456.6557	8454.4790	8285.3894	8200.8446
21		4384.9310	4383.7778	4296.1023	4252.2644	21		8879.4885	8877.2029	8699.6589	8610.8868
22		4593.7372	4592.5292	4500.6786	4454.7532	22		9302.3213	9299.9269	9113.9284	9020.9291
23		4802.5435	4801.2805	4705.2549	4657.2420	23		9725.1541	9722.6508	9528.1978	9430.9713
24		5011.3497	5010.0318	4909.8312	4859.7308	24		10147.9867	10145.3748	9942.4673	9841.0135

SELECTING THE *RIGHT* FIELD HOUSING IS *IMPORTANT...*



It's good employee relations to see that oil field workers have comfortable homes. It is good business to select field housing that has proved right for the oil industry for almost 35 years.

STURDYBILT Prefabricated Houses are *right* for the oil fields because they are economical, easy to erect, can be moved from one site to another, and are handsome and comfortable enough to suit the most particular oil field family.

Get the RIGHT field housing. Order STURDYBILT Prefabricated Houses.

■ WRITE FOR INFORMATION

MANUFACTURERS OF SPECIAL MILLWORK: DISTRIBUTORS OF JOHNS-MANVILLE BUILDING MATERIALS: CURTIS WOODWORK

STURDYBILT PREFABRICATED, DEMOUNTABLE HOUSES

SOUTHERN MILL & MANUFACTURING CO. • TULSA, OKLAHOMA

phmi PREFABRICATED HOME MANUFACTURERS' INSTITUTE

STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD CS125 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES

UNIVERSAL CONVERSION FACTORS

CENTIMETER =

0.0000062137	miles
0.00001	kilometers
0.000049709	furlongs
0.0001	hektometers
0.00049709	chains
0.001	dekameters
0.0019884	rods
0.01	meters
0.010936	yards
0.011811	varas (Texas)
0.032808	feet
0.043744	spans
0.049709	links
0.098424	hands
0.1	decimeters
0.3937	inches
1.00	centimeters
10	millimeters
393.70	mils
10,000	microns
10,000,000	milli-microns
10,000,000	micro-millimeters
100,000,000	Angstrom units
15,531.6	wave lengths of red line of cadmium

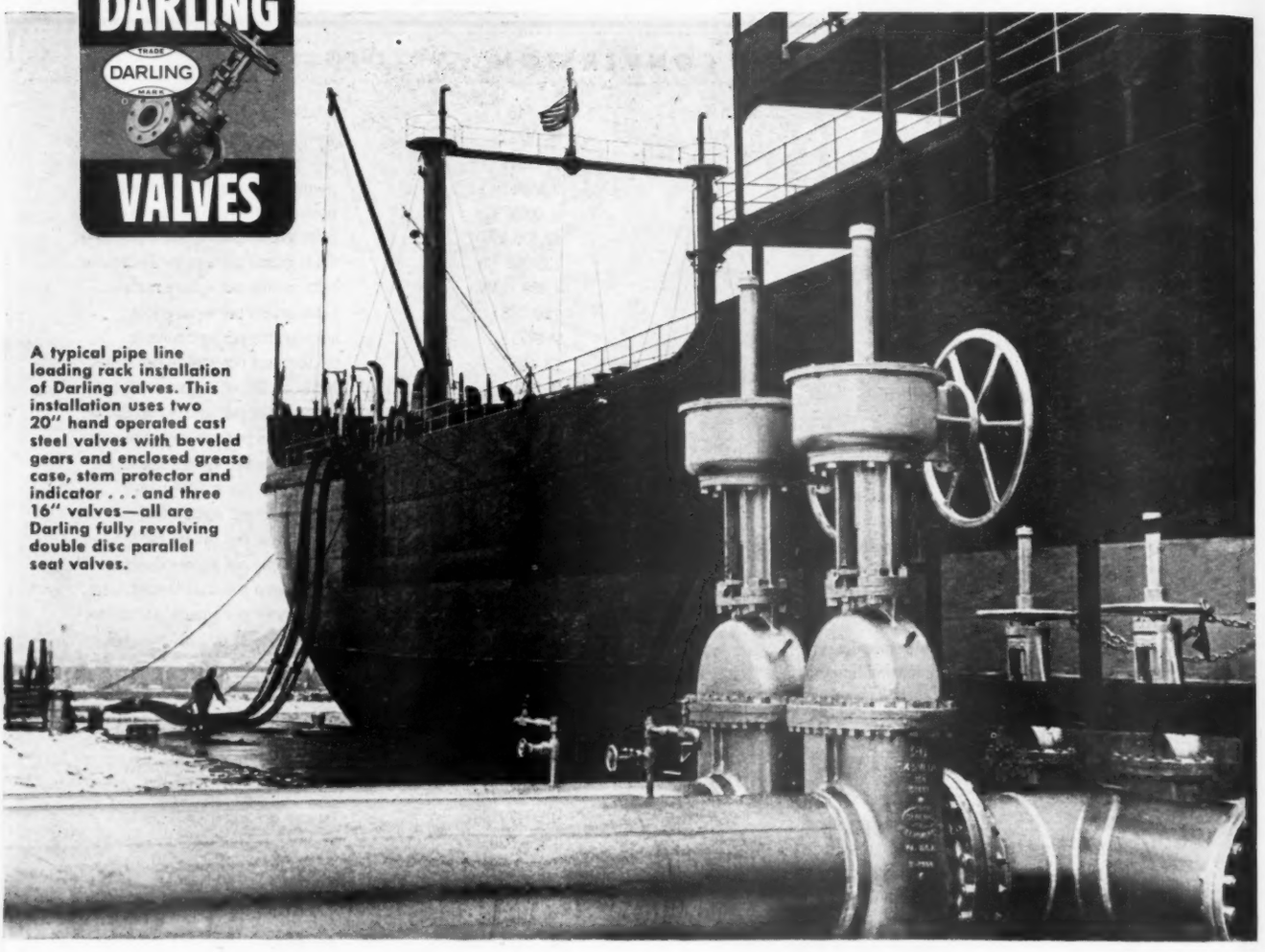
CENTIMETER OF MERCURY (0° C) =

0.0013595	hektometers of water @ 60° F.
0.013595	dekameters of water @ 60° F.
0.13595	meters of water @ 60° F.
0.44604	feet of water @ 60° F.
0.44604	ounces of water @ 60° F.
5.35248	inches of water @ 60° F.
1.35952	decimeters of water @ 60° F.
13.595299	centimeters of water @ 60° F.
135.95299	millimeters of water @ 60° F.
0.0001	hektometers of mercury @ 32° F.
0.001	dekameters of mercury @ 32° F.
0.01	meters of mercury @ 32° F.
0.032808	feet of mercury @ 32° F.
0.032808	ounces of mercury @ 32° F.
0.3937	inches of mercury @ 32° F.
0.1	decimeters of mercury @ 32° F.
1.0	centimeters of mercury @ 32° F.
10.0	millimeters of mercury @ 32° F.
1,498.62505	tons per square hektometer
14,98625	tons per square dekameter
0.14986	tons per square meter
0.013923	tons per square foot
0.000096685	tons per square inch
0.0014986	tons per square decimeter
0.000014986	tons per square centimeter
0.00000014986	tons per square millimeter
1,359,529.9	kilograms per square hektometer
13,595.299	kilograms per square dekameter
135.95299	kilograms per square meter
12.63034	kilograms per square foot
0.087711	kilograms per square inch
1.35953	kilograms per square decimeter
0.013595	kilograms per square centimeter
0.00013595	kilograms per square millimeter
2,997,249.93506	pounds per square hektometer
29,972.49935	pounds per square dekameter
299.7250	pounds per square meter
27.845	pounds per square foot
0.19337	pounds per square inch
2.99725	pounds per square decimeter
0.029973	pounds per square centimeter
0.00029973	pounds per square millimeter
13,595,299	hektograms per square hektometer
135 952.99	hektograms per square dekameter
1,359.5299	hektograms per square meter
126.3034	hektograms per square foot
0.87711	hektograms per square inch
13.5953	hektograms per square dec meter
0.13595	hektograms per square centimeter
0.0013595	hektograms per square millimeter
135,952,990	dekagrams per square hektometer
1,359,529.9	dekagrams per square dekameter
13,595.299	dekagrams per square meter
1,263.0 4	dekagrams per square foot
8.7711	dekagrams per square inch
135.95299	dekagrams per square decimeter
0.013595	dekagrams per square millimeter
1.35953	dekagrams per square centimeter
47,955,999	ounces per square hektometer
479,560	ounces per square dekameter
4,795.6	ounces per square meter
445.520	ounces per square foot
3.09392	ounces per square inch
47.9560	ounces per square decimeter
0.479560	ounces per square centimeter
0.00479560	ounces per square millimeter
1,359,529,900	grams per square hektometer
13,595,299	grams per square dekameter
135,952.99	grams per square meter
12,630.34	grams per square foot
87.71111	grams per square inch
1,359.5299	grams per square decimeter
13.595299	grams per square centimeter
0.13595	grams per square millimeter
13,595,299,000	decigrams per square hektometer
135,952,990	decigrams per square dekameter
1,359,529.9	decigrams per square meter
126,303.4	decigrams per square foot
877.11111	decigrams per square inch
13,595.299	decigrams per square decimeters
135.95299	decigrams per square centimeter
1.35953	decigrams per square millimeter
135,952,990,000	centigrams per square hektometer
1,359,529,900	centigrams per square dekameter
13,595,299	centigrams per square meter
1,263,034	centigrams per square foot
8,771.1111	centigrams per square inch
135,952.99	centigrams per square decimeter
1,359.5299	centigrams per square centimeter
13.595299	centigrams per square millimeter
1,359,529,900,000	milligrams per square hektometer
13,595,299,000	milligrams per square dekameter
135,952,990	miliigrams per square meter
12,630,340	milligrams per square foot
87,711.1111	milligrams per square inch
1,359,529.9	milligrams per square decimeter
13,595.299	milligrams per square centimeter
135.95299	milligrams per square millimeter
0.013333	bars
0.013158	atmospheres
1,322,220,000,000	dynes per square hektometer

Compiled by Steven Gerolde, Gulf Oil Corporation

DARLING

VALVES



A typical pipe line loading rack installation of Darling valves. This installation uses two 20" hand operated cast steel valves with beveled gears and enclosed grease case, stem protector and indicator . . . and three 16" valves—all are Darling fully revolving double disc parallel seat valves.

How they help keep cargo schedules with DARLING Revolving Disc GATE VALVES

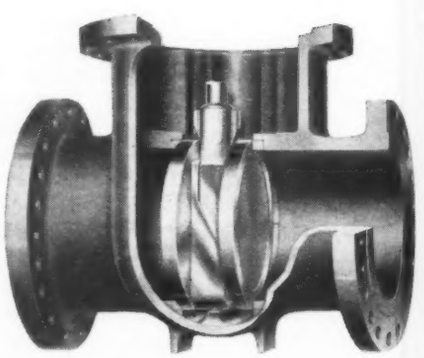
TROUBLE-FREE valve service on tanker loading racks is helping to build an enviable valve service record for Darling *fully revolving double disc parallel seat* gate valves.

The big advantage here, as in all Darling *revolving disc* gate valve installations, is the cut in down time. These unique cast steel gate valves automatically compensate for valve body distortion. Moreover, Darlings give better service longer because their *fully revolving double discs* distribute disc and seat wear uniformly. And Darling valves are always easier to operate, even under severe pressure loads or radical changes in temperature.

You save time too when it does become necessary to service Darling valves because all working parts can be replaced without removing the valves from the line. And any one, or all of the four working parts, can be quickly replaced on the spot.

Wide Range of Sizes

These Darling *fully revolving double disc parallel seat* gate valves are available in a wide range of sizes and types for all gas and oil line requirements. Ask for general descriptive literature or outline your specific service needs so we can send you the exact information you need.



Cutaway showing the extreme simplicity of Darling's unique fully revolving double disc parallel seat gate valve principle.

DARLING VALVE & MANUFACTURING CO.

Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario

UNIVERSAL CONVERSION FACTORS

CENTIMETER OF MERCURY (O°C) (Continued)

13,332,200,000	dynes per square dekameter
133,322,000	dynes per square meter
12,385,916.01	dynes per square foot
86,013.3056	dynes per square inch
1,333,220	dynes per square decimeter
13,332.20	dynes per square centimeter
133.3220	dynes per square millimeter

CENTIMETER PER SECOND PER SECOND =

0.000006214	miles per second per second
0.00001	kilometers per second per second
0.000049709	furlongs per second per second
0.0001	hektometers per second per second
0.00049709	chains per second per second
0.001	dekameters per second per second
0.0019884	rods per second per second
0.01	meters per second per second
0.010936	yards per second per second
0.011811	varas (Texas) per second per second
0.032808	feet per second per second
0.043744	spans per second per second
0.049709	links per second per second
0.098424	hands per second per second
0.10	decimeters per second per second
0.3937	inches per second per second
1.00	centimeters per second per second
10.00	millimeters per second per second
393.70	mils per second per second
10,000	microns per second per second

CHEVAL-VAPEUR (METRIC HORSEPOWER) =

62,832,926.34	foot poundals
753,995,116.08	inch poundals
1,952,910	foot pounds
23,434,920	inch pounds
0.69727	ton (short) calories
632.551	kilogram calories
1,394.53604	pound calories
6,325.51	hektogram calories
63,255.1	dekagram calories
22,312.57664	ounce calories
632,551	gram calories
6,325,510	decigram calories
63,255,100	centigram calories
632,551,000	milligram calories
17.64 8	kilowatt days
0.7352	kilowatt hours
0.012533	kilowatt minutes
0.00020422	kilowatt seconds
30.633333	watt days
735.2	watt hours
44,120	watt minutes
2,646,720	watt seconds
297.62401	ton meters
270,000	kilogram meters
595,248.02	pound meters
2,700,000	hektogram meters
27,000,000	dekagram meters
9,523,968.32	ounce meters
270,000,000	gram meters
2,700,000,000	decigram meters
27,000,000,000	centigram meters
270,000,000,000	milligram meters
2.97624	ton hektometers
2,700	kilogram hektometers
5,952.4802	pound hektometers
27,000	hektogram hektometers
270,000	dekagram hektometers
95,239.6832	ounce hektometers
2,700,000	gram hektometers
27,000,000	decigram hektometers
270,000,000	centigram hektometers
2,700,000,000	milligram hektometers
29.7624	ton dekameters
27,000	kilogram dekameters
59,524.802	pound dekameters
270,000	hektogram dekameters
2,700,000	dekagram dekameters
952,396.832	ounce dekameters
27,000,000	gram dekameters
270,000,000	decigram dekameters
2,700,000,000	centigram dekameters
27,000,000,000	milligram dekameters
9.07158	ton feet
82,296	kilogram feet
181,431.5965	pound feet
822,960	hektogram feet
8,229,600	dekagram feet
2,902,905.54394	ounce feet
82,296,000	gram feet
822,960,000	decigram feet
8,229,600,000	centigram feet
82,296,000,000	milligram feet
0.75596	ton inches
6858	kilogram inches
15,119.29971	pound inches
68,580	hektogram inches
685,800	dekagram inches
241,908.79536	ounce inches
6,858,000	gram inches
68,580,000	decigram inches
685,800,000	centigram inches
6,858,000,000	milligram inches
2,976.24	ton decimeters
2,700,000	kilogram decimeters
5,952,480.2	pound decimeters
27,000,000	hektogram decimeters
270,000,000	dekagram decimeters
95,239,683.2	ounce decimeters
2,700,000,000	gram decimeters
27,000,000,000	decigram decimeters
270,000,000,000	centigram decimeters
2,700,000,000,000	milligram decimeters
29,762.4	ton centimeters
27,000,000	kilogram centimeters
59,524,802	pound centimeters
270,000,000	hektogram centimeters
2,700,000,000	dekagram centimeters
952,396,832	ounce centimeters
27,000,000,000	gram centimeters
270,000,000,000	decigram centimeters
2,700,000,000,000	milligram centimeters
297,624	ton millimeters
270,000,000	kilogram millimeters
595,248,020	pound millimeters

Compiled by Steven Gerolde, Gulf Oil Corporation

Legend

- Branch Stores with Service Facilities
- Sales Offices

- CORPUS CHRISTI
- DALLAS
- HOBBS
- HOUSTON
- KILGORE
- McALLEN
- NEW IBERIA
- ODESSA
- PAMPA
- SHREVEPORT
- SNYDER
- WICHITA FALLS

Wherever your operations are located in Texas, western Louisiana, or New Mexico, the strategically placed repair shops of Waukesha Sales and Service, Inc., mean that you are close to the best in fast, economical repair facilities. So, for service on your Waukesha Engine or Kohler Electric plants and air-cooled engines, take advantage of our personalized attention that keeps your operations running smoothly and reduces your downtime to a minimum.

WAUKESHA

Sales & Service, Inc.

1422 MAURY STREET • HOUSTON, TEXAS

EXCLUSIVE DISTRIBUTORS FOR WAUKESHA PRODUCTS IN TEXAS, LOUISIANA AND NEW MEXICO

UNIVERSAL CONVERSION FACTORS

CHEVAL-VAPEUR (METRIC HORSEPOWER) (Continued)

2,700,000,000	hektogram millimeters
27,000,000,000	dekagram millimeters
9,523,968,320	ounce millimeters
270,000,000,000	gram millimeters
2,700,000,000,000	decigram millimeters
27,000,000,000,000	milligram millimeters
26.1298	kiloliter atmospheres
261.298	hektoliter atmospheres
2,612.98	dekaliter atmospheres
26,129.8	liter-atmospheres
261,298	deciliter-atmospheres
2,612,980	centiliter-atmospheres
26,129,800	milliliter-atmospheres
0.00000002613	cubic kilometer-atmosphere
0.00002613	cubic hektometer-atmosphere
0.02613	cubic dekameter-atmosphere
26.1298	cubic meter-atmospheres
922.74776	cubic feet-atmospheres
26,129.8	cubic decimeters-atmospheres
26,129,800	cubic centimeter atmospheres
26,129,800,000	cubic millimeter atmospheres
2,648,700	joules
.0410967	horsepower days
0.98632	horsepower hours
59.17920	horsepower minutes
3550.752	horsepower seconds
0.171945	pounds of carbon oxidized with 100% efficiency
2.5877	pounds of water evaporated from and at 212° F
2510.152	B.T.U.

CUBIC CENTIMETER =

0.00000000000000062137	cubic miles
0.000000000000001	cubic kilometers
0.000000000000122833	cubic furlongs
0.000000000001	cubic hektometers
0.000000000122833	cubic chains
0.000000001	cubic dekameters
0.0000000078613	cubic rods
0.000001	cubic meters
0.000001	kiloliters
0.0000013079	cubic yards
0.0000016476	cubic varas (Texas)
0.0000062897	barrels
0.00001	hectoliters
0.000028378	bushels-U.S. (dry)
0.000027496	bushels-Imperial (dry)
0.000035314	cubic feet
0.000083707	cubic spans
0.0001	dekaliter
0.000113512	pecks
0.000122833	cubic links
0.00026417	gallons-U.S. (liquid)
0.00022705	gallons-U.S. (dry)
0.00021997	gallons-Imperial
0.00095635	cubic hands
0.0010567	quarts (liquid)
0.00090808	quarts (dry)
0.001	liters
0.001	cubic decimeters
0.0021134	pints (liquid)
0.0018162	pints (dry)
0.0084536	gills (liquid)
0.01	deciliters
0.061023	cubic inches
0.1	centiliters
1	milliliters
1	cubic centimeters
1000	cubic millimeters
0.033814	ounces (fluid)
0.27051	drams (fluid)

CUBIC FOOT =

0.000000000017596	cubic miles
0.000000000028317	cubic kilometers
0.0000000034783	cubic furlongs
0.000000028317	cubic hektometers
0.0000034783	cubic chains
0.000028317	cubic dekameters
0.00022261	cubic rods
0.028317	cubic meters
0.028317	kiloliters
0.037036	cubic yards
0.046656	cubic varas (Texas)
0.17811	barrels
0.28317	hectoliters
0.80358	bushels-U.S. (dry)
0.77860	bushels-Imperial (dry)
2.37033	cubic spans
2.8317	dekaliters
3.2143	pecks
3.48327	cubic links
7.48050	gallons-U.S. (liquid)
6.42937	gallons-U.S. (dry)
6.22889	gallons-Imperial
27.08096	cubic hands
29.92257	quarts (liquid)
25.71410	quarts (dry)
28.317	liters
28.317	cubic decimeters
59.84515	pints (liquid)
51.4934	pints (dry)
239.38060	gills (liquid)
283.17	deciliters
1,727.98829	cubic inches
2,831.7	centiliters
28,317	milliliters
28,317	cubic centimeters
28,317,000	cubic millimeters
957.51104	ounces (fluid)
7,660.03167	drams (fluid)
0.9091	sacks of cement (set)
62.35	pounds of water @ 60° F.
64.3	pounds of salt water
72.0	pounds of salt water at 60° F. of 1.155 specific gravity
489.542	pounds of steel of 7.851 specific gravity

CUBIC FOOT PER MINUTE =

256.47840	barrels per day
10.68660	barrels per hour
0.17811	barrels per minute
0.0029685	barrels per second

Compiled by Steven Gerolde, Gulf Oil Corporation

LAUGH with BARNEY

A farmer's barn had burned down and the agent from the insurance company arrived to discuss the claim. Explaining the policy that covered the structure, the agent told the farmer that his firm would build another barn of similar size instead of paying the claim in cash.

The farmer was outraged.

"If that's the way your company does business," he exploded, "you can just cancel the insurance policy on my wife!"

A hard-bitten mountaineer approached the window and announced that he had come for a marriage license for his daughter Nellie and her boy friend.

"Where's the groom-elect?" asked the clerk.

"What d'ya mean, groom-elect?" asked the hillman. "There warn't no election. I made the appointment myself."

Sizmo Sam says: A smart girl is one who knows how to play tennis, golf, piano . . . and dumb!

"Mandy," he began, "Ah is got a house, Ah got money in de bank. Will you marry me?"

"Ah sho will, Honey Chile," replied Mandy, "but would you all mind tellin' me who dis is speakin'?"

The thing opened most often by mistake is the human mouth.

Husband and wife were in the midst of a violent quarrel, and hubby was losing his temper.

"Be careful," he said to his spouse. "You'll bring out the beast in me."

"So what?" she replied. "Who's afraid of mice?"

One evening a young matron was returning from a first aid class when she came upon a man sprawled face down on a darkened side street.

"Ah," the woman muttered to herself, "how fortunate that one with my first aid training should happen upon this poor accident victim." Whereupon she hopped out of her car, rushed to the prostrate man and began artificial respiration.

Presently the man stirred, looked up, and — speaking with some difficulty — said: "Look, lady, I'm holding a lantern for a guy working down in this manhole. I'm not sure what you're up to, but this ain't the time or the place!"

The Russian school teacher asked a pupil, "Who were the first human beings?"

"Adam and Eve," the kid replied.

"And what nationality were they?"

"Russian, of course."

"Fine, fine," the teacher commented. "And how did you know they were Russians?"

"Easy," said the kid. "They had no roof over their heads, no clothes to wear, and only one apple for the two of them — and they called it Paradise!"

Bars are something which, if you go into too many of, you are apt to come out singing a few of, and maybe land behind some of.

On the second day of the honeymoon, a bridegroom left the hotel room long enough to get out for a newspaper. When he came back, he found his wife in the arms of a bellboy.

She looked at her husband coyly and said, "I bet you think I'm an awful flirt."

"It's oil, young lady . . . LANE-WELLS on the job"

"I hope, Mrs. Smith," the neighbor spoke up indignantly, "that you have spoken to your boy about mimicking me on the street."

"I certainly have, Mr. Brown," replied the woman. "I told him not to go around acting like a fool in public!"

A tractor salesman was going along a back country road when he saw a farmer plowing his field with a bull hitched to the plow. Thinking this should be a likely prospect, he stopped his car, got out and went over to high pressure the farmer.

He made his pitch and then asked the farmer if he wouldn't like to buy a tractor. The farmer replied, "I've got a tractor in the barn."

"Then why in the world are you using this primitive method of plowing?"

The farmer answered, "I aim to teach this critter that there's something else in life besides romance!"

Professor Crubish was a renowned hand at exploring and digging in ancient ruins; but when it came to making love, he was a pretty awkward sort of a chap. One night, however, as he rested his head on his beloved's bosom, he felt impelled to express himself.

"You know, dear," he said anxiously, "resting here like this gives me a great happiness — only once before in all my life have I felt so relaxed."

"When was that?" asked his girl friend suspiciously.

"One night in Egypt," explaned the professor innocently, "when I camped between two of the Pyramids."

"Let me kiss those tears away, sweetheart," begged the petroleum engineer. She fell into his arms and he was very busy for a few moments, but the tears flowed on.

"Will nothing stop them?" he asked breathlessly.

"No," she murmured, "it's hay fever, but go on with the treatment."

In a certain business establishment signs had been posted on every wall, bearing the single imperative word, "Think!"

Apparently the experiment in initiative didn't work out too well. A few weeks later they were replaced by new signs that read, "Don't think. Ask!"

One night Sam came home with lipstick on his collar. "Where did you get that?" demanded his wife. "From my maid?"

"No," Sam replied.

"From the governess?" she snapped.

"No," repeated Sam, adding indignantly, "Don't you think I have any friends of my own?"

"Lord, fill my mouth with worthwhile stuff,
And nudge me when I've said enough."

A guide showing an old lady over the zoo, took her to a cage occupied by a kangaroo.

"Here, madame," he said, "we have a native of Australia."

The visitor stared at it in horror.

"Good heavens!" she said, "and to think my niece married one of them things."

Student: Could you help me with this problem?

Professor: I could, but I don't think it would be quite right.

Student: Well, take a shot at it anyway.

OIL and GAS TRADE NEWS

Brown Fintube Licenses Friedrich Uhde GMBH

Brown Fintube Company, Elyria, Ohio, has licensed Friedrich Uhde GMBH, 21b Dortmund, West Germany to manufacture and sell the company's products in West Germany and other countries in Europe, Africa, and the Middle East. Brown Fintube is originator of Brown resistance welded integrally bonded Fintubes.

Rockwell Completes Gas Meter Plant

Rockwell Manufacturing Company has opened a new 19,000-sq ft addition to its gas meter plant in DuBois, Pennsylvania, L. A. Dixon, Jr., vice president of the meter and valve division, announced. With the opening of the new addition, Dixon said, DuBois has become the nation's largest gas meter manufacturing center. Among the new products to be manufactured in the new addition, are Rockwell's lightweight "800" aluminum gas meter and a number of other Rockwell aluminum domestic and industrial gas meters.

Dand to Handle Pumps For Gorman-Rupp in Canada

H. E. Rupp, president of the Gorman-Rupp Company, announced that W. R. Dand Petroleum Equipment, Ltd., of Toronto, Ontario, has been licensed to manufacture Gorman-Rupp pumps for petroleum transfer and refueling service in Canada. The firm will begin production early in the year. Plans have been approved and contracts let for a new, modern plant in Toronto. Licensing of Dand, Ltd., to produce and distribute Gorman-Rupp products is a part of the Mansfield company's long range development program, he continued.

W. R. Dand specializes in all types of equipment for the petroleum industry, and has been a Gorman-Rupp pump distributor for twenty years, the line including bulk plant and tank truck meters.

New Sales Set-Up Reported By Lufkin Rule Company

E. H. Meibeyer, vice president of The Lufkin Rule Company, has announced that in order to make its national sales program more effective the company has established two new regional sales divisions, which, together with the New York division and the West Coast division, divided the country into four sales areas for the company.

William F. Rockwell will be sales manager of the new East Central division. He began with Lufkin in 1934. D. F. Oltz will be sales manager of the new West Central division. He joined Lufkin in 1951.

In order to better co-ordinate administrative matters in the sales department, Thomas W. Wise has been made assistant to Meibeyer. He will also work on the planning and analyses of sales division operations and objectives.

Knight-Gordon Are Agents

Oil Metering and Processing Equipment Corporation of Houston has announced the appointment of Knight-Gordon Engineering Company of Tulsa as their representative in Oklahoma and Kansas.

A. Knight

M. Gordon

Oil Metering manufactures well testers, test separators, gas scrubbers, free water knockouts, and other equipment. Art Knight and Milt Gordon are partners in the Knight-Gordon Company.

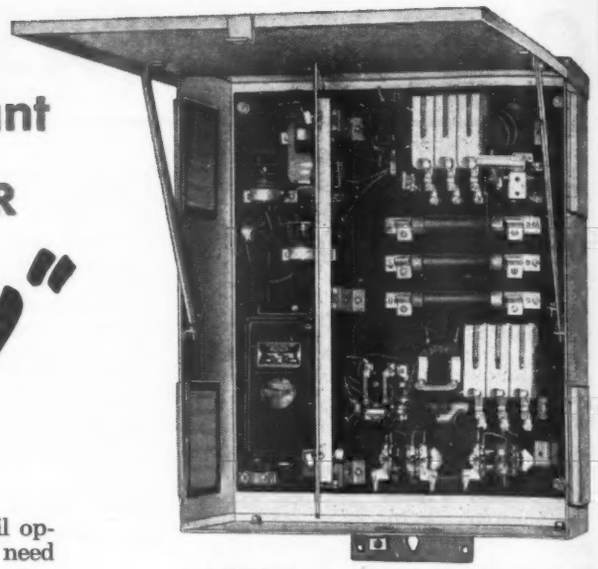
Montana Office Open

Lane-Wells Company has opened a new sales office at 111 North 30th Street, Billings, Montana, telephone 99984. Don Bishop has been transferred from Casper, Wyoming, as district sales engineer. This will bring the total of sales and service branches to 75 in the United States.

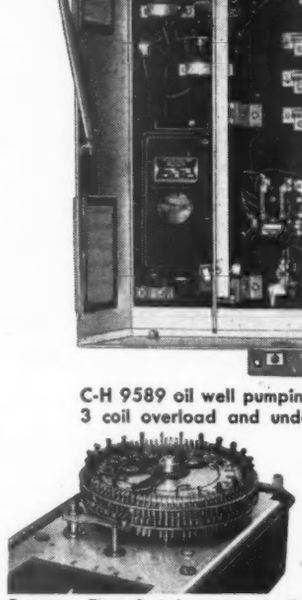
ATTENDING recent annual sales meeting of Merla Tool Corporation in Dallas are: First row, C. D. Fletcher, John Valdez, Roy A. Lamb, Howard Shireman, V. A. Kagay and John Eads. Second row, Clif Mock, Odell Shaw, R. Henke, J. D. Phillips, Malcolm Hudson, J. Robison, and George Kingsley. Third row, M. H. Kirkgard, Art Robinson, Lloyd Gwinn, Randall Larkin, and B. J. Rhoads, Jr.

At the same time, new officers for Merla Tool were elected as follows: Roy A. Lamb, president; V. A. Kagay, secretary and general manager, and R. D. Henke, director.

We give you what you want in genuine CUTLER-HAMMER "Oil Country" well pumping control



C-H 9589 oil well pumping controller with 3 coil overload and undervoltage relay.



Program Time Switch automatically schedules pumping, set up easily by pull tabs—one for each 15 minute interval. Day omission feature also available, for non-operation any selected days of week.

Cutler-Hammer went to the oil country to find out what oil operators, practical production men, maintenance crews really need and want in their oil well pumping control.

And Cutler-Hammer Oil Country Control *proves out.* The practical way in which heat is shielded out and fresh clean air pours in around the working mechanism proves out. You never see C-H control with the door propped open to keep it working.

The extraordinary care to keep out dirt, large particles of dust and bugs proves out. Louvres, bronze-screening and baffle plates do their work. And the famous C-H Vertical dust safe contacts shed dirt and dust to keep clean, sure contacts. Timer is neoprene-gasketed and dust proof. And the excess torque time clock keeps going if inadvertently dust gets in.

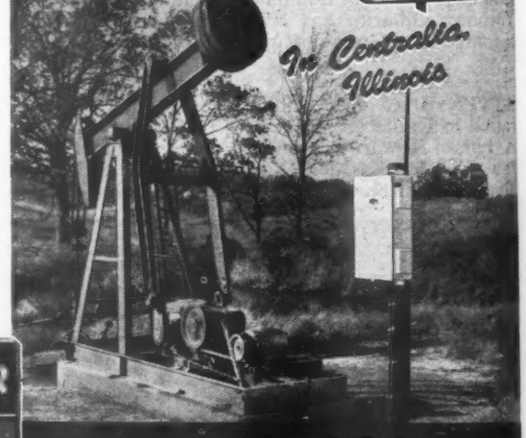
Undervoltage relay if you want manual restarting. Automatic time delay if you want automatic staggered starting of groups of motors.

Full three phase protection with 3 coil overload relays if you want to avoid motor burnouts which can result from single phasing.

Pumping sequence changes are made in 15 minute increments. You just pull small, accessible tabs. Day omission feature is also available on the time programming switch when your scheduling calls for skip-a-day pumping.

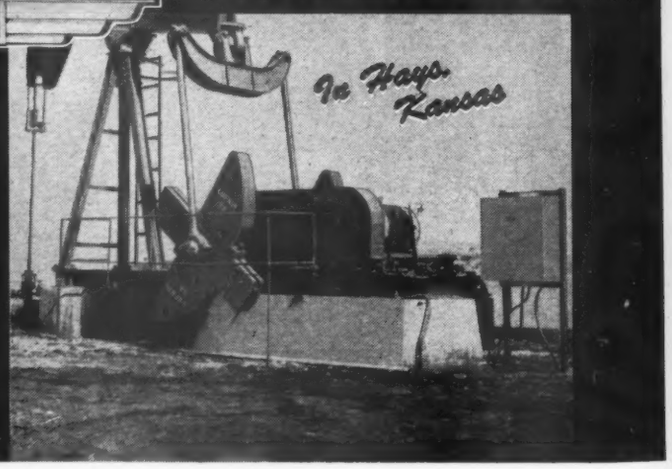
Unit type lightning arresters that tell at a glance if they've blown and eliminate the need to clean up or rebuild the starters.

There are so many wanted features on these controllers, there is not room enough to tell them all. Ask for further information. Or better still, try out a C-H starter and compare it with the performance of any other make you have ever had. CUTLER-HAMMER, Inc., 1459 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.



CUTLER-HAMMER
MOTOR CONTROL
C-H

MEMBER AMERICAN PETROLEUM INSTITUTE



Schmidt Heads Up New Pipe Line Engineering Firm

E. H. Schmidt and Associates, Inc., has opened offices in Tulsa, Oklahoma, specializing in pipe line field engineering work and civil engineering.

E. H. Schmidt

President and manager of the firm is Ed H. Schmidt, of Tulsa, formerly an engineer with Stanolind Pipe Line Company, and Ford, Bacon and Davis, Inc.

Schmidt, a graduate of the University of Missouri, was with the Missouri State Highway Department and with the Chicago, Milwaukee, St. Paul, and Pacific Railroad out of Ottumwa, Iowa.

Following his war service, he was partner and chief pipe line engineer of Southern Mapping and Engineering Company, and later with the Universal Map and Survey as vice president and general manager in charge of engineering.

Jones & Laughlin Make Changes in Organization

Several organizational changes in the Jones and Laughlin Steel Corporation—supply division have been announced.

The Dallas-Fort Worth sales office is to be divided, each being a separate sales office. Guy A. McDaniel will be manager of the Dallas sales office and R. Z. Dallas will be manager of the Fort Worth sales office. Frank J. Kopp, formerly of the combined office, will continue his headquarters in Dallas.

A sales office is also being established at San Antonio, Texas, with John W. Kaye as sales office manager. The district office of the Southwest Texas district is to be at Corpus Christi, Texas, with Vance H. Weldon, Jr., as district sales manager. New headquarters of the North Rocky Mountain district will be 3302 Fourth Avenue North, Billings, Montana, and M. A. Park will continue as district sales manager. This district will now be comprised of the oil field supply stores of the company at Powell, Wyoming, Glendive and Cut Bank, Montana, and Williston, North Dakota. District office of the South Rocky Mountain district will be at 4975 Colorado Boulevard, Denver, Colorado, and Doyne Carson will continue as district sales manager.

BS&B Has New Trade Name

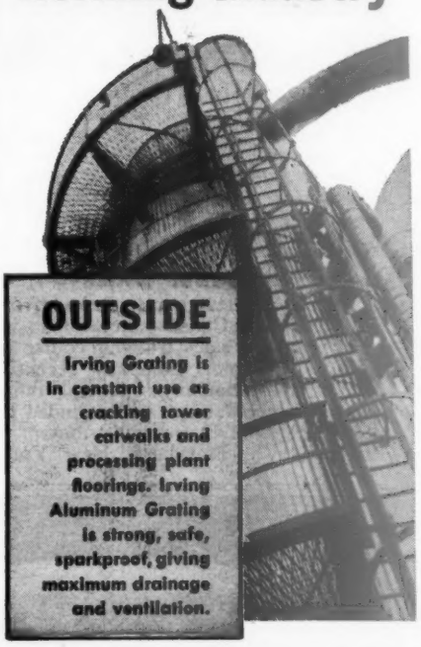
Black, Sivalls and Bryson, Inc., announces a new trade name—Cold-Frac—covering its line of low temperature separation equipment. The name Cold-Frac describes the process of these systems: Separation of natural gas from its condensable fractions at low temperature and subsequent stabilization or fractionation of the condensate to specification product. All systems in Cold-Frac line are made up of separate elements of BS&B standard products.

HUGHES DISTRICT MANAGERS and company executives at the new Hughes research and engineering laboratory, where they met recently to review plans for 1954. They are: Bottom row, W. H. Siems, general sales manager and M. E. Montrose, vice president—sales. Second row, M. A. Foreman, D. W. Potts, J. R. Kunkel, A. H. LeBlue. Third row, R. A. Crosby, Dr. Daniel J. Martin, vice president—engineering, Chester S. Johnson, vice president and secretary, and A. F. Briscoe. Fourth row, W. L. Barnes, S. R. Mays, Floyd L. Scott, director of research, and John McCauley. Fifth row, J. R. Mathis. Top row, P. A. Percy, Harry E. Rogers, vice president—manufacturing, S. S. Cobb, and R. R. Brownridge.

OUTSIDE AND INSIDE

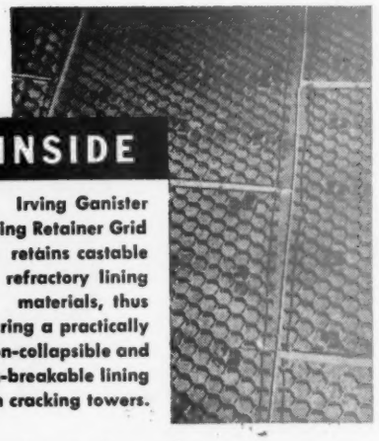
IRVING GRATING

Serves the Refining Industry



OUTSIDE

Irving Grating is in constant use as cracking tower catwalks and processing plant floorings. Irving Aluminum Grating is strong, safe, sparkproof, giving maximum drainage and ventilation.



INSIDE

Irving Ganister Lining Retainer Grid retains castable refractory lining materials, thus assuring a practically non-collapsible and non-breakable lining in cracking towers.

For Further Information on Irving Gratings, Write

IRVING SUBWAY GRATING CO., INC.

ESTABLISHED 1902

OFFICES and PLANTS at
5052 27th St., Long Island City 1, N. Y.
1852 10th St., Oakland 20, California

LUNKENHEIMER PERSONNEL and sales representatives at conference: Bottom row, Melvin W. Pauly, M. D. Kinner, Dennis D. O'Brian, J. O. Crawford, Jr., E. F. Harrison, B. F. Verdin, J. A. Cummings, William L. Robinson, J. C. Stilwell, William N. Frederick, Bud Ranck, M. R. Conran, William E. Peterson, and Rean McElroy. Middle row, L. M. Crowe, J. H. Wick, R. M. Bennett, C. W. Reitz, J. E. Jenny, W. LeGrow, Russell Fisher, Robert McLean, Jr., E. Duncan Cameron, Philip DeWitt, J. W. Sanders, Ed Lipster and Harold H. Layritz. Top row, David C. Jones, Jr., R. T. Klein, I. A. Orth, G. E. Regensburger, Guy Givens, Al Vickers, C. W. Bundscho, D. McIntyre, Jr., G. P. Curry, A. J. Shimer, J. Stroup, K. A. Ziel, R. N. Juhas, T. H. Pyle.

Training Course Held At Lunkenheimer Office

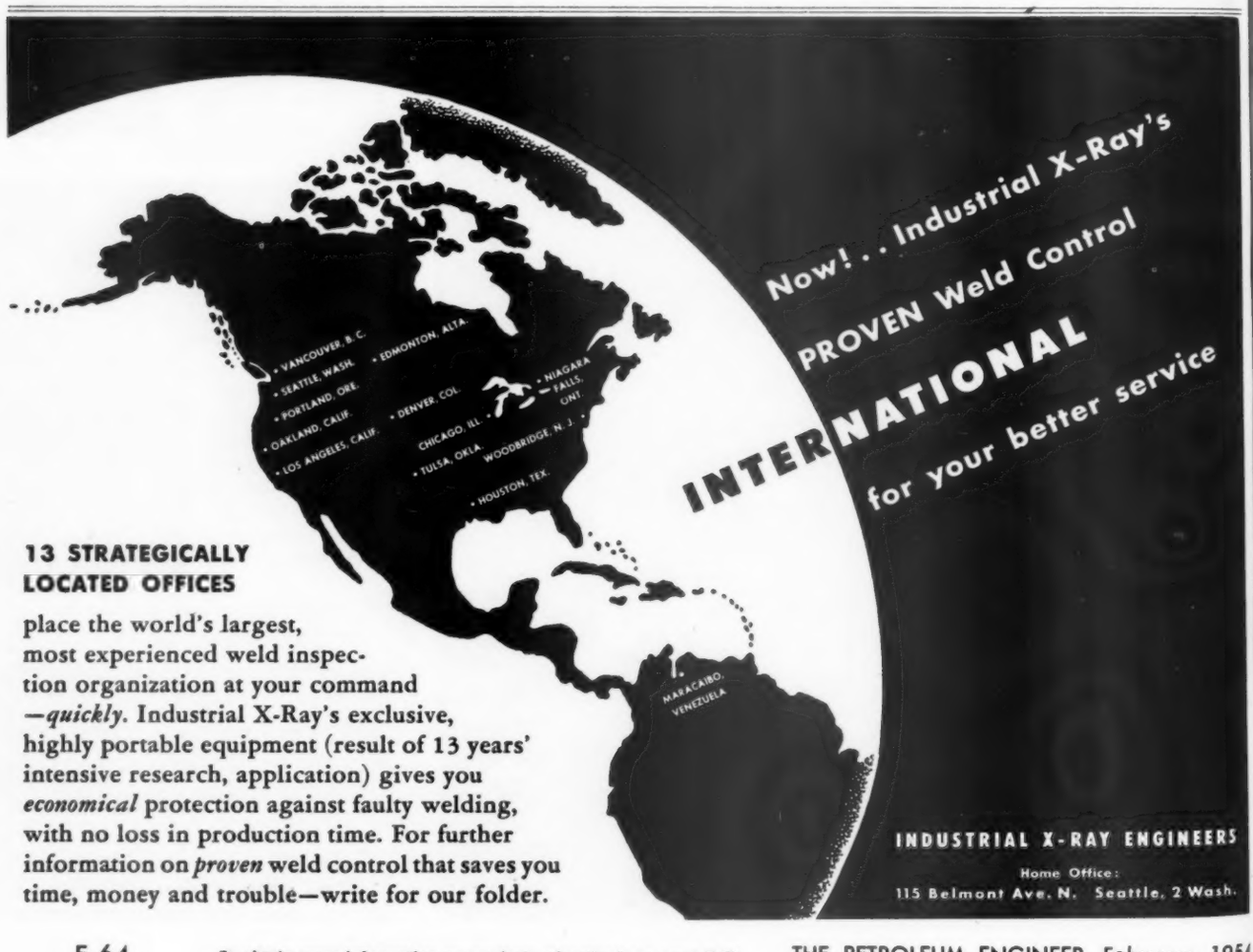
Distributor sales representatives from eight states and Canada attended an intensive two-day sales training course at The Lunkenheimer Company recently. Held at the company's general office building, the conference was attended by sales representatives from distributors in Georgia, Iowa, Maryland, New York, Ohio, Pennsylvania, South Carolina, and West Virginia, and Canada.

Principal emphasis of the sales conference was placed on the use of the Lunkenheimer Guide as a sales tool, etc.

The conference was under the direction of Harry A. Burdorf, vice president in charge of sales; Melvin W. Pauly, Eastern and Western, and Harold H. Layritz, sales manager, central divisions.

G-A Buys Storage Terminal

Jerome S. Selig, vice president in charge of tank storage terminals, has announced that General American Transportation Corporation has purchased and will operate the tank storage terminal of Phillips Petroleum at Pasadena, Texas. W. A. Buckner, superintendent of terminal at Galena Park, Houston, Texas, will supervise the Pasadena, Texas, terminal.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CHICAGO, ILL.
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13 STRATEGICALLY LOCATED OFFICES
place the world's largest, most experienced weld inspection organization at your command —quickly. Industrial X-Ray's exclusive, highly portable equipment (result of 13 years' intensive research, application) gives you economical protection against faulty welding, with no loss in production time. For further information on proven weld control that saves you time, money and trouble—write for our folder.
INDUSTRIAL X-RAY ENGINEERS
Home Office:
115 Belmont Ave. N. Seattle, 2 Wash.

TRADE PERSONALS

Loyd W. Moore has been promoted to district manager United Supply and Manufacturing Company, West Texas and New Mexico division. Moore who has

L. W. Moore D. Johnson R. B. Northrup

been with the company for 13 years, was district manager of the North district. **Roger B. Northrup** is now area manager of the West Texas and New Mexico division with headquarters in Dallas. He has been with the company since 1941. **Don Johnson,** the new assistant district manager of stores in West Texas and New Mexico, will continue to have his headquarters in Midland, Texas.

Tom E. Morton has been transferred to Houston, Texas, as assistant division manager and division engineer of Halliburton Oil Well Cementing Company's South Texas division. He was formerly stationed at Dallas in the same capacities. Morton joined Halliburton in 1941 following his graduation the previous year from the University of Oklahoma.

S. R. Pittman, formerly district sales engineer, Lane-Wells Company, at Williston, North Dakota, has been appointed district sales engineer at Healdton, Oklahoma. **Charles L. Naus,** formerly station superintendent of Glendive, Montana, has been made district sales engineer at Williston. **Robert L. Jenkins,** operator No. 2 at Williston, has been promoted to station superintendent at Glendive.

C. E. Buchan has been named to the newly created position of general sales manager Electric Machinery Manufacturing Company. A veteran of thirty years with E-M, Buchan has been the Cleveland district manager for the past 25 years. His successor as Cleveland district manager will be **J. J. Wall,** for the past four years a sales engineer in the New York district office. A veteran of World War II, Wall has 10 years of experience in the application of alternating current power machinery.

W. C. "Dub" Gray, who for the last 10 months has been Security's Gulf Coast manager, has been transferred to the post of Oklahoma division manager, while **Clarence Strait,** former Oklahoma division manager, moves to the Gulf Coast division manager post. Gray, who recently returned from a year's leave of absence, first joined Security in 1945. He has served as sales manager for Oklahoma, Gulf Coast, and Security Engineering, at Edmonton, Alberta, Canada. Strait came to Security in 1948.

John Garrett has been promoted to the newly created position of vice president and sales manager of Goodall Rubber Company of Texas. Garrett is a specialist in rotary hose and has been a salesman for Goodall of Texas for five years. He received his degree from Newark College of Engineering and did graduate work at MIT.

Walter W. Stake, formerly assistant general sales manager, A. O. Smith Corporation, for the Permaglas-Heating division stationed in New York, has been named regional manager for the eastern district. He succeeds the late Russell J. Irish, who headed the new York office. **Allen O. Dragge,** who has had jurisdiction over the West Coast operations, now has been named regional manager of the Pacific Coast district for A. O. Smith.

Charles E. Heitman, manager of the automotive division of A. O. Smith Corporation, has been named to fill the newly-created post of assistant to the general manager of the company.

Heitman has managed the division largely since 1946. He has been with the company since 1940.

William J. Klein, manager of the Minneapolis branch, tractor division, Allis-Chalmers Manufacturing Company, has been named vice president and general sales manager of the tractor division. Klein began his career with Allis-Chalmers as a salesman in 1928. In 1929 he was made a special factory representative and in November, 1930 he opened the company's Minneapolis branch.

AN ELECTRICAL LOG interpretation conference was presented recently by Schlumberger Well Surveying Corporation in the lecture room at its new Houston plant. Pictured are representatives of oil companies who attended the conference. They are: First row, R. E. Lowry, Humble; G. B. Brown, Tennessee Production Company; E. Sugar, Creole Petroleum; C. V. Wilson, Colorado Interstate Gas; F. W. Brupbacher, Sun Oil; C. D. Smith, Union Producing; R. W. Allen, El Paso Natural Gas; F. S. Daniel, Humble. Second row, J. B. Terry, Richardson and Bass; Ray George and J. D. Owen, Phillips; K. R. Stout, Trafford and Associates; R. L. Porter, Sinclair; L. G. Huntley, Carter; C. R. Hoagland, K. A. Ellison Consultants; K. W. Roth, Amerada; E. E. Tucker, Tide Water; W. J. Bates, J. M. Huber Corporation; J. D. Tuohy, International Petroleum. Third row, R. D. Ottmann, Humble; K. E. Merren, McAlester Fuel; G. C. Borland, New York State Natural Gas; E. Clements, Richardson and Bass; C. W. Muil, Humble; T. Walker, Atlantic Refining; B. Barron, Humble; J. E. Carothers, Phillips; W. W. McMahan, Jr., Magnolia; T. Wilson, Jr., Ohio Oil. Not in the picture were: Guy Joyce, Union Sulphur, and Ed Mulanovich, International Petroleum, Ltd.

Trade Personals

Kenneth H. Klipstein has been appointed general manager of the newly created research division of American Cyanamid Company. This division will be responsible for the operation of the Stamford Research Laboratories under the direction of Dr. J. T. Thurston.

A new division known as the organic chemicals division of American Cyanamid has been organized, with **L. C. Duncan** as general manager and **V. E. Atkins,** assistant general manager.

Another change has created the fine chemicals division of American Cyanamid with **A. B. Clow** as general manager and **A. R. Loosli,** assistant general manager.

The new pigments division will be responsible for the production and sale of titanium dioxide and other pigments formerly handled by the Calco chemical division. **J. Allegaert** has been named general manager and **A. B. Hettrick,** assistant general manager.

Henry Schottler, German inventor, has been appointed to the engineering staff of Oil Center Tool company to assist in research and the development of new tools.

H. Schottler

Schottler will use his experience in inventing in Germany in developing new tools to add to the O-C-T line. His career as an inventor goes back 32 years, his first item being a time saving tool.

M. G. Lucke has been named superintendent of moulded hose, Quaker Rubber Corporation, division of H. K. Porter Company, Inc. Lucke will be in charge of all moulded hose production for the company.

G. R. Winder, vice president and general sales manager, and **K. K. Knutzen,** secretary, treasurer, and comptroller of Chiksan Company, have just returned to Brea, California, after a two week trip to Chiksan of Canada Ltd., a subsidiary of Chiksan Company. During their stay in Canada, Winder and Knutzen visited the Edmonton and Calgary offices of the Canadian subsidiary, and called on major customers and prospects with **Jack Runnells,** Western Canadian district sales manager, and **David Cormack,** sales representative.

George A. Pryor, salesman—Jones and Laughlin Products, was promoted to assistant sales manager—J&L Products and has assumed supervision of the sale of JSL tubular products and wire rope in the Gulf Coast area and in Southwest Texas.

George E. Tyson, salesman—J&L Products, has been promoted to the newly-created position of sales engineer—J&L Products. Tyson enter the employ of Jones and Laughlin Steel as a salesman at Houston in 1938.

Harold A. Edlund has been promoted to the post of general sales manager of the Butler Manufacturing Company. Edlund joined Butler in May, 1952, and has been assistant general sales manager. He is a graduate of the University of Pennsylvania's Wharton School.

Maurice C. Bickert has been named as district engineer, Marlow Pumps. He will cover the four state Mid-Atlantic district consisting of Southern Pennsylvania, New Jersey, Delaware, and Maryland from headquarters in Ridgewood. Bickert, who recently completed the Marlow Training Course, came to the company from Wallace and Tiernan.

M. C. Bickert

J. L. North

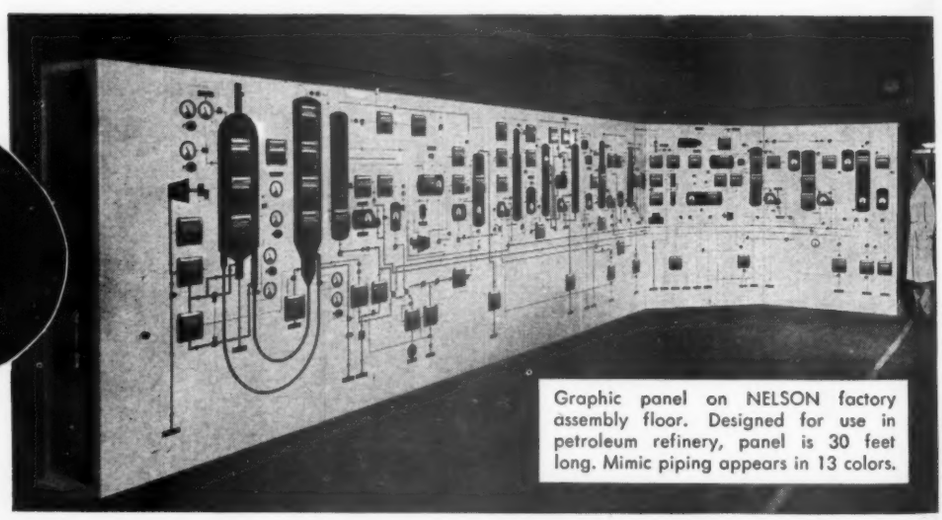
John L. North has been named assistant to sales manager with headquarters in Ridgewood. Prior to his association with Marlow, North worked for Hinds and Dauch Paper Company.

Sidney M. Blair of Toronto has been elected president of Canadian Bechtel Ltd. Blair has been vice president and a director of Canadian Bechtel, and has been associated with Bechtel since 1949.

Gordon W. Reed, chairman of the board, and **Harry O. King,** member of the board of directors of Glass Fibers, Inc., have been presented with the Award for Meritorious Civilian Service for their outstanding accomplishments as special consultants to the Air Force during recent years. Presentation of the Award was made by Secretary of the Air Force Harold E. Talbott.

A third recipient of the award at the same ceremony was **Jacob Saliba,** a special consultant to Glass Fibers Inc.

ONE STOP SERVICE



Graphic panel on NELSON factory assembly floor. Designed for use in petroleum refinery, panel is 30 feet long. Mimic piping appears in 13 colors.

. . . for PIPED AND WIRED GRAPHIC CONTROL PANELS

When you purchase a graphic control panel from Nelson Electric Manufacturing Company, we produce that panel *complete!*

At our factory we mount all instruments and controls. Instrumentation is piped to bulkhead fittings and wired to terminal blocks as required. All graphic symbols are applied. Inspection of the entire assembly is most exacting.

The panel is then shipped to your plant site as a completed unit, ready to install.

When you need a panelboard, permit us to quote on your requirements.

NELSON Electric MANUFACTURING CO.
TULSA, OKLAHOMA

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TELEPHONE 2-5131

Trade Personals

A. Morazzani has been put in charge of the Rocky Mountain area of Schlumberger Well Surveying Corporation with headquarters in Denver, replacing **Paul D. Chabas** who became manager of headquarters service in the corporation's offices at Houston. Morazzani, formerly manager of the Northeast area, came to

A. Morazzani

W. B. Steward

Schlumberger Well Surveying in 1937.

New manager in the Northeast is **J. E. Armstrong.** Armstrong has been assistant area manager at Evansville, Indiana. At Houston headquarters, **W. B. Steward,** formerly head of the administration department was appointed administrative assistant to the vice president of engineering.

G. K. Miller, formerly associate development engineer, went to the Schlumberger Research Center recently as assistant to the research department head.

Jack N. Yetter has been named manager of sales promotion of the Twin Disc Clutch Company, and **Mel H. Woodward** as Yetter's successor as manager of the Tulsa, Oklahoma district.

Yetter's previous duties with Twin Disc have been district sales engineer, assistant district manager, and district manager of the Tulsa office. Woodward joined Twin Disc at the Tulsa office as installation engineer.

J. P. Moran has been promoted to district engineer for Dowell Incorporated's Houston district. Moran, who will make his headquarters in Houston, succeeds **E. F. Kelly** who has been transferred to Midland, Texas, as district engineer for Dowell in the Permian Basin. Moran, a graduate of Ohio State University, has been with Dowell six years.

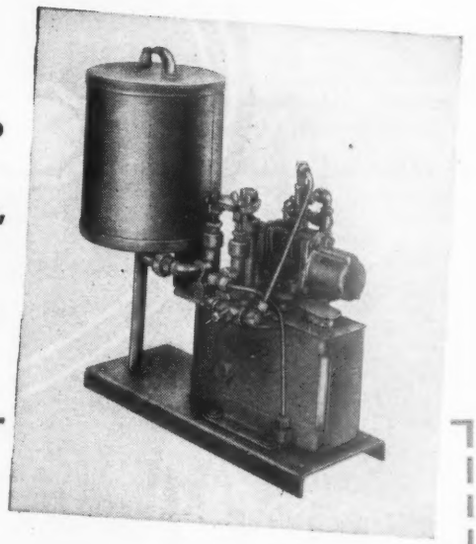
H. E. McNeill is being transferred from Lafayette, Louisiana, to Alice, where he will be area engineer. McNeill, graduated from the University of Texas, has been with Dowell three years. He was station manager at Lafayette at the time of his transfer.

Bob White's appointment as representative in the South Texas area has been announced by Oil Metering and Processing Equipment Corporation. White's territory will include the lower Gulf Coast area from the south side of Fort Bend County to Brownsville.

J. J. Meany has been named vice president of The A. V. Smith Engineering Company. In this capacity he will be responsible for corrosion studies made in the field.

Make SURE machinery keeps operating

• For the solution to lubrication difficulties, or chemical feeding problems, more and more companies are turning to Manzel.



...for example:

Chemical Feeders are used throughout the oil industry to keep wells and pipelines in good, flowing condition. *But,* in wet gas fields corrosion frequently stops the motors that power these feeders.

To solve this problem, Manzel developed a chemical feeder with built-in automatic force feed lubrication which protects the gas motor from corrosion and insures continuous operation of the feeder.

For 50 years a leader in the field, Manzel is today a flexible, fast-moving organization with the special technical skill for meeting your needs quickly and economically. Write for further information about Manzel Force Feed Lubricators and Chemical Feeders.

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Safeguard high priced machinery with
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... CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS

New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) HIGH PRESSURE METERS

A new, low throughput meter has been added to the A. O. Smith line of high pressure meters. The new model, WPM-2, is designed for 300 psi working pressure and has a tentative maximum rating of 20 gpm. Fitted with 1-in. screw connections, it has outside dry adjustment and takes any of the standard SMITHway counters.

Circle letter (A) on reply card.

(B) WELDING PROCEDURES

Ampco 8 sheet and plate, which is available in all thicknesses for fabrication, can be welded by all of the arc-welding processes, i.e., carbon-arc, metal-arc, inert-gas tungsten-arc, inert-gas consumable electrode and submerged-arc, Ampco Metal, Inc., spokesmen report. Detailed welding procedures are available.

Circle letter (B) on reply card.

(C) REFRACTORY LININGS

The George P. Reintjes Company announces a new development in the design of refractory supports, which includes requirements mentioned below.

The refractory lining of the catalyst regenerators necessitates use of suspended wall constructions. Effectiveness of the suspended refractory wall, however, is no better than the design and type of suspension that is used. It is necessary that suspension used is capable of supporting the dense refractories against downward. inward. or outward movement.

Circle letter (C) on reply card.

(D) PRESSURE PICKUP

Where pressure transients occur too rapidly for observation with conventional indicating devices, the new electrical resistance-Type 4-312 pressure pickup provides immediate response to pressure changes. This latest of Consolidated Engineering's miniature pickups is available in gage, absolute, and differential models which feature high corrosion resistance and a flush-type diaphragm. It may be used for either liquid or gaseous measurements.

Circle letter (D) on reply card.

(E) TOWING TRACTOR

The Frank G. Hough Company has just announced a new 1954 model of the TC-60 "Payloader" towing tractor. It is claimed that the refinements and modifications which contribute to greater ease of control, convenience and usefulness have been added without sacrificing basic features such as compactness of design. maneuverability, and a drawbar pull of 6000 lb.

The dual-range, full-reversing transmission has been provided with a solenoid vacuum-actuated tail-shaft brake.

Circle letter (E) on reply card.

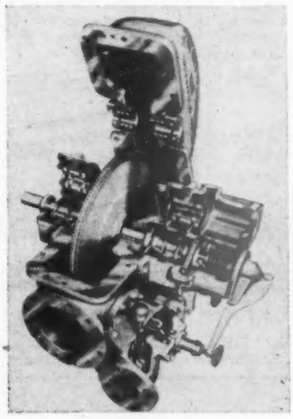
(F) PLASTIC CLAMP

The Carlon Products Corporation has announced development and production of a molded plastic clamp utilized to effect a tight, permanent seal when sections of flexible plastic pipe are connected by means of insert couplings, tees, ells, and adapters. It is slipped over the pipe ends and tightened to force them down onto the serrations incorporated in insert fittings to create a leakproof connection.

Circle letter (F) on reply card.

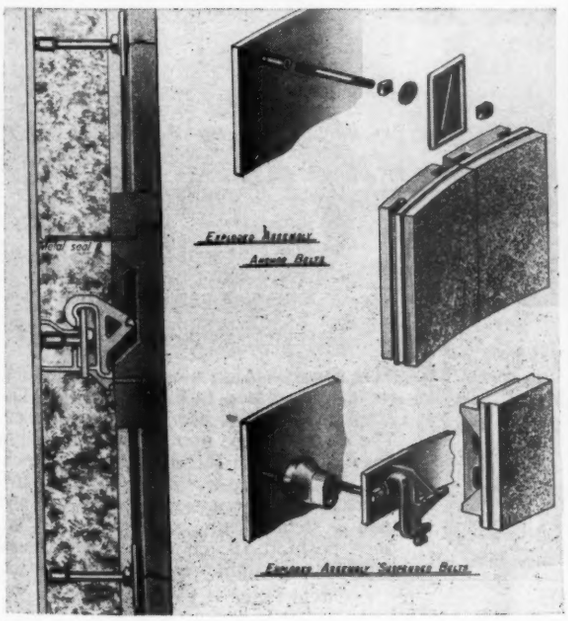
(G) HORIZONTAL TURBINES

The Dean Hill Pump Company announces new improvements in the entire DH line of horizontal turbines. A major change was the addition of a steam nozzle to all models. The new, two-nozzle DH-10 and DH-20 turbines have doubled the maximum horsepower of former units. The DH-10 is now equipped with water-cooled bearings and a maximum of four carbon rings instead of three. A redesigned governor and trip valve eliminates the use of packing on valve stems.

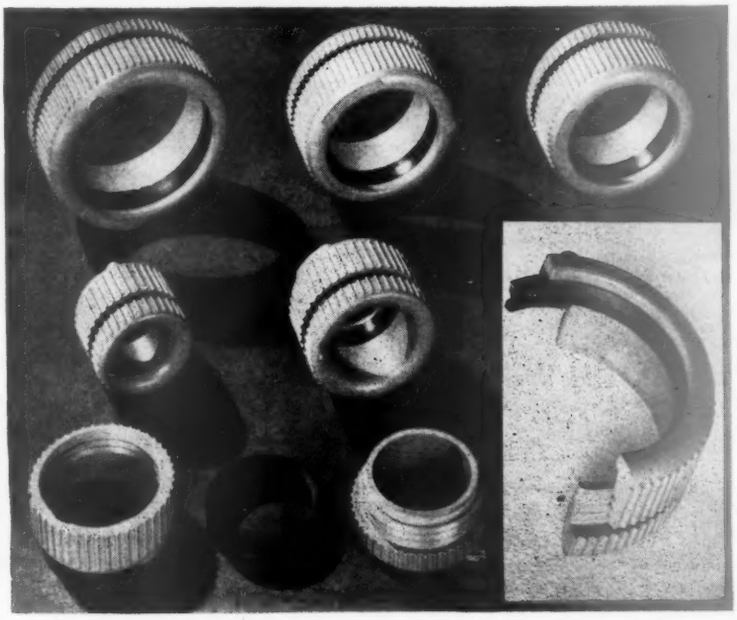


Circle letter (G) on reply card.

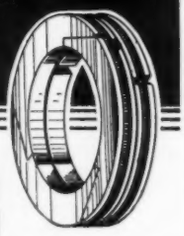
G. P. Reintjes' latest refractory linginos design.



Carlon Products' molded plastic clamps.



MAXIMUM CHOICE OF MATERIALS
when you use these
METALLIC PACKINGS
produced by
FRANCE



For your special packing problem, we will specify:
- CAST IRON RINGS—for moderate pressures.
- BRONZE RINGS—for high pressures, high temperatures.
- CARBON-BAKELITE RINGS—where poor lubricating conditions or wet, sour gas exists.
- CARBON RINGS—for non-lubricated service.
- BABBITT RINGS—for stainless steel rods.

And, of course, all these Metallic Packing Rings have the FRANCE tangent-cut, step joint design that assures maximum service.
SPECIFY FRANCE METALLIC PACKINGS.

Write for Complete Information

MAXIMUM SERVICE for you in our NEW PLANT

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(H) HYDROCARBON INDICATOR

A portable instrument for field technicians to detect hydrocarbons in cores, samples, and drilling fluids at well sites, has been developed by Atlas Exploration Company. It removes guesswork from coring, clearly indicates types of hydrocarbons present, approximate top and bottom of probable producing zones, and selects those cores that require additional lab analysis. Fido, name given the instrument, has built-in fluorescent light peaked at 3660 AU, the optimum ultra-violet wave length to show all petroleum fluids. Other features include gas collecting syringes, stainless steel core crusher, gas collector for drilling fluids, stainless steel hammer, pick, and core trays.

Circle letter (H) on reply card.

(I) AIR HYDRAULIC JACK

A new type jack incorporating the use of 80 to 100 lb of compressed air to operate a separate hydraulic pump has been announced by the Duff-Norton Manufacturing Company. The new combination jack and ram consists of a choice of four hydraulic rams—4½, 7½, 10, and 28 in. in length—which can move 30 tons in any direction a distance of 2, 3½, 6 and 20 in. The air motor is mounted on a portable buggy and comes complete with 50 ft of ½-in. air hose and 6 ft of flexible hydraulic hose.

Circle letter (I) on reply card.

(J) MECA COUPLING

Designed especially to simplify the process of connecting tubing or pipe, Master Enterprise Corporation of America's new Meca coupling requires no threading, flares, ferrules, or tools, it has been reported. Press the spring clip, insert the tube, release the spring. One of the principles of the coupling is the grooving of the interior. At each end are grooves containing rubber O-rings or silicone or tefalon rings. The sleeve is tapered on the inside to allow for any variation in the outside diameter of the tubing or pipe. Coupling is available in all sizes.

Circle letter (J) on reply card.

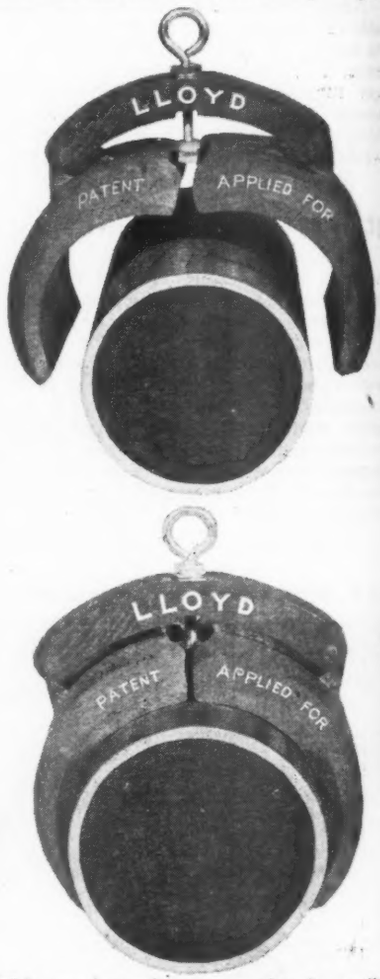
(K) SEPARATOR, FILTER

A new patented filter that removes 100 per cent of water from diesel and other fuels is being introduced in 1954 by the Fram Corporation. The new unit, functioning entirely different from any fuel filter yet developed, is the Fram water separator and fuel filter. Fram has thoroughly field tested the new filter before adding it to the company's complete line of primary and secondary fuel filters.

Circle letter (K) on reply card.

(L) RIVER CLAMP WEIGHT

The Lloyd Metal Foundry has just announced to the pipe line trade its newest invention known as a river clamp-weight.

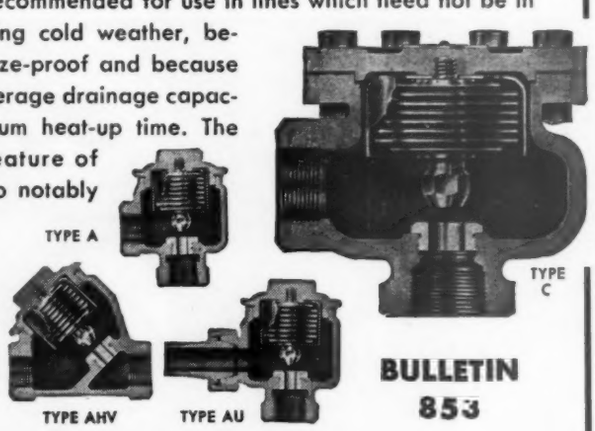


This new invention now makes it possible for a river clamp to be applied to a line after the line has been laid in a trench. The clamp can be applied by one man in one minute with the use of one wrench. The river clamp-weight is built in two sections with a connecting lever arm and uses a stem locking mechanism. In the open position, the clamp can be lowered unto the pipe until weights make contact.

Circle letter (L) on reply card.

NICHOLSON MAKES
Freeze-Proof Steam Traps
for every Plant Use

Because they drain completely when cold, these four types of Nicholson steam traps are positively freeze-proof. Can be freely installed outdoors. Universally recommended for use in lines which need not be in continuous use during cold weather, because they are freeze-proof and because their 2 to 6 times average drainage capacity results in minimum heat-up time. The non-air-binding feature of Nicholson traps also notably facilitates heat transfer in severe weather. Types for every plant use. Sizes ¼" to 2"; pressures to 250 lbs.



BULLETIN 853

217 OREGON ST., WILKES-BARRE, PA.

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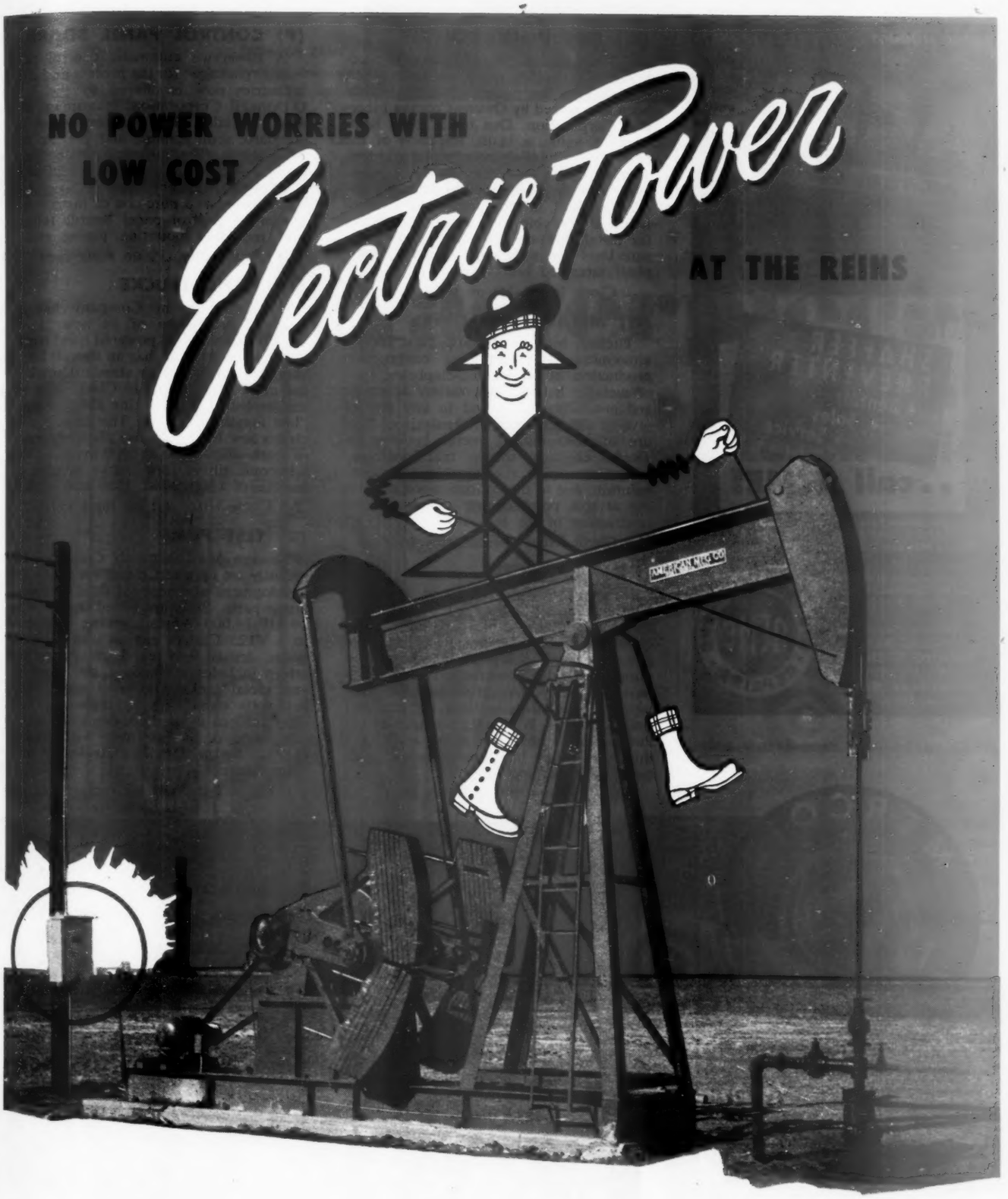

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Write for catalog No. 700A.

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New Equipment

(M) PIPE INSULATION

A low pressure pipe insulation for economical and efficient use on cold water, hot water, or low pressure steam lines, has been announced by Owens-Corning Fiberglas Corporation. Due to its extra heat-stopping value, a ½-in. thickness of the new pipe insulation equals the performance of ¾ to 1-in. thicknesses of many other materials commonly used in the low pressure field, the company reports. Insulation is available with a canvas covering for installation on hot water or low pressure lines and with a black jacket of asphalt saturated kraft paper.

Circle letter (M) on reply card.

(N) METALLIC BELLOWS

Titeflex, Inc., of Newark, New Jersey, announces it is beginning commercial production of its welded-diaphram type of metallic bellows in a variety of standard production sizes and in any one of several different metals. Analysis of failure of conventional metal bellows by Titeflex engineers showed that failure occurred mainly at the bend in each convolution, due to the concentration of flexing at this point during expansion and contraction of the bellows.

Circle letted (N) on reply card.

(O) CARTRIDGES

Enabling quick changes in the field with a minimum loss in pumping time, is the new and exclusive cartridge design construction of the Gorman-Rupp Company vertical self-priming centrifugal pump. Cartridge construction permits removal of pump element without breaking pipe. It is a safety spillage reducer and time saver. G. W. Stahl, manager of industrial and petroleum pump sales says this new feature has been included in all new "O" series models.

Circle letted (O) on reply card.

(P) CONTROL PANEL BOARD

A 10-service automatic control panel board "package" for the process and allied industries now is offered by the J. P. O'Donnell Corporation, instrument division. Included in the arrangement are standard, semi-graphic, and graphic control boards. The instrumentation "package" consists of instrumentation planning by corporation and clients' engineers; specification and purchase of instruments; design of control panel board; fabrication, including mounting, piping, etc.

Circle letter (P) on reply card.

(Q) HAND TRUCKS

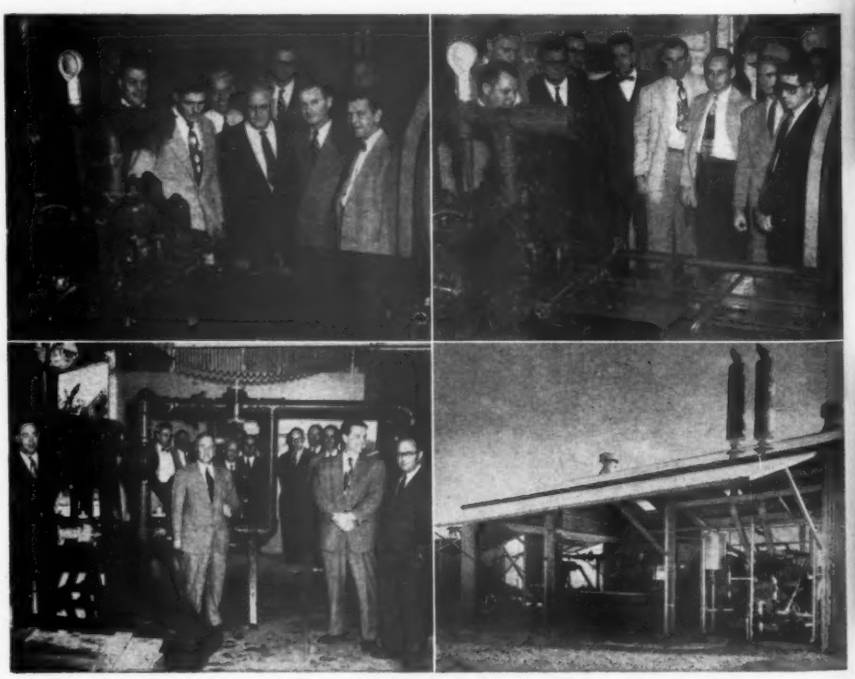
Clark Equipment Company has announced production of its new "Powrworker 26-in. line of powered hand trucks. The Powrworker 26 has an overall length shorter than any other standard truck on the market, according to Clark. This was accomplished by reducing the maximum "lost length" to 26 in. The new line includes low lift pallet and platform trucks in both 4000-lb and 6000-lb capacities; telescopic tilting fork trucks in base capacities of 1500, 2000, 2500 and 3000 lb.

Circle letter (Q) on reply card.

(R) TEST PUMP

Mission Manufacturing Company has recently set up a test pump for study and development of improved fluid end slush pump parts. Parts are tested in a 7½ by 14 HP-14,000 Wheland pump connected to a V125 Climax engine, and operated under actual field conditions. The test set-up includes a standard size mud pit and metal tanks. Old mud taken from field pits containing cuttings and high sand content is used to duplicate actual conditions. A cooling tower with cooling coils in the mud tank controls the mud temperatures.

Circle letter (R) on reply card.

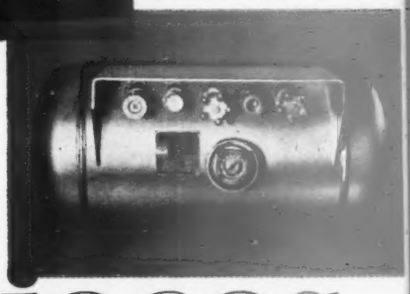


SHELL OIL men, upper right, who inspected Mission's test stand were: Fritz Haselker; Jim Lewis; H. E. Arnold; Richard White and H. Ben Young of Mission; J. A. Burgbacher; G. D. Oates; C. O. Bell of Mission; W. S. Phillips; and J. S. Stewart of Mission. A group from Humble Oil & Refining, lower left, included: H. M. Lemex; H. Ben Young, and Miller Sparks of Mission; Charles Dunlop and George Campbell of Wheland Pump; C. O. Bell of Mission; Tucker Pennington, Neil Taylor; Dudley Sharp of Mission; J. W. Rhea, W. M. O'Reilly, and G. E. Cannon.

XUM

STORAGE TANKS
LPG, Anhydrous Ammonia
and Gasoline

LPG and
Gasoline
FUEL TANKS



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of steel construction

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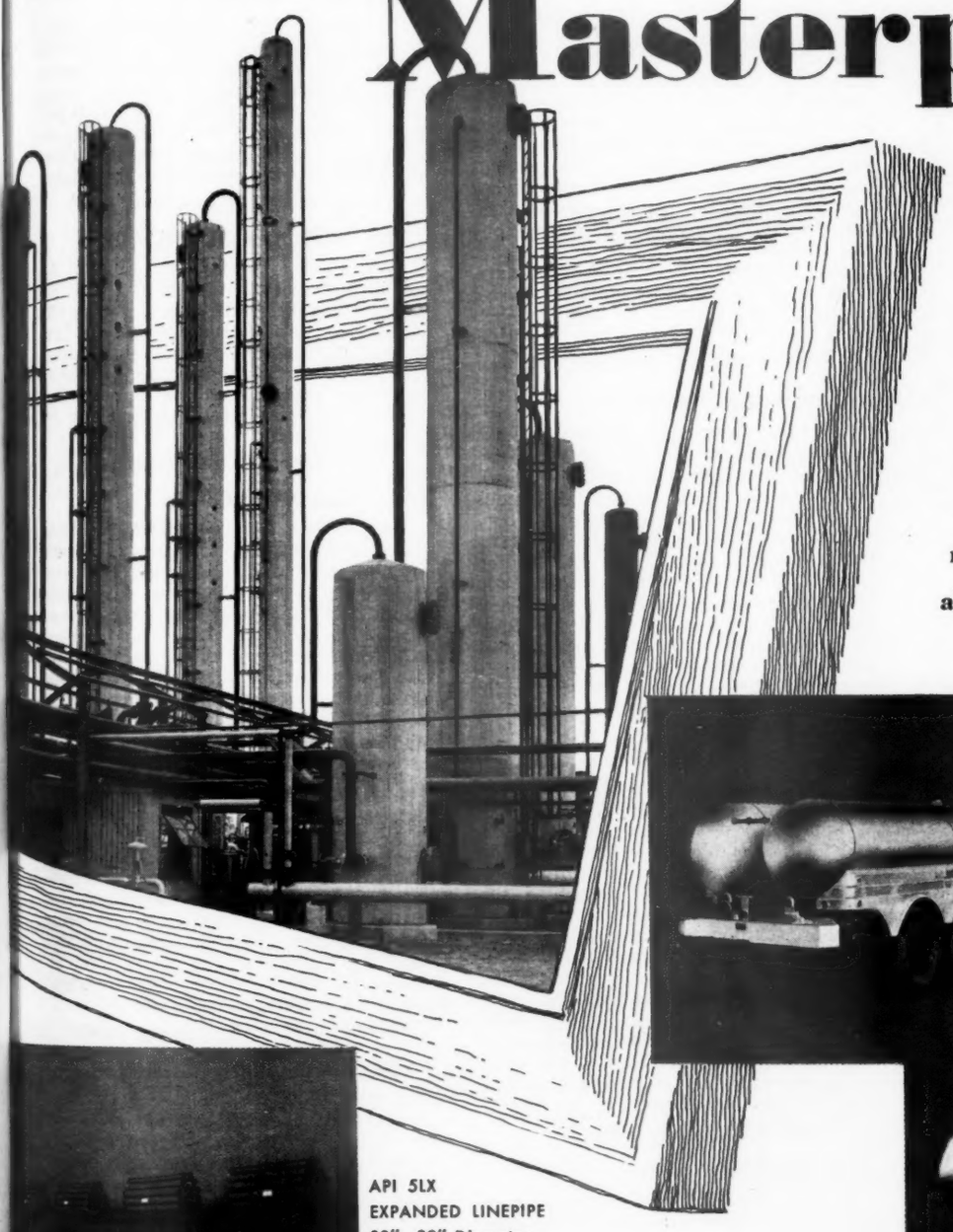
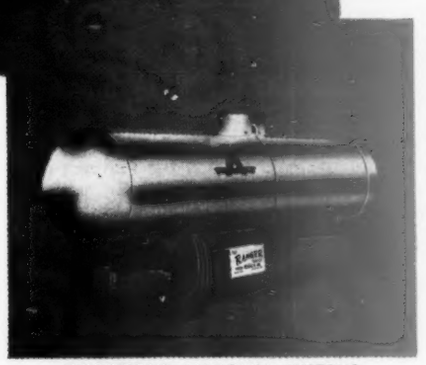


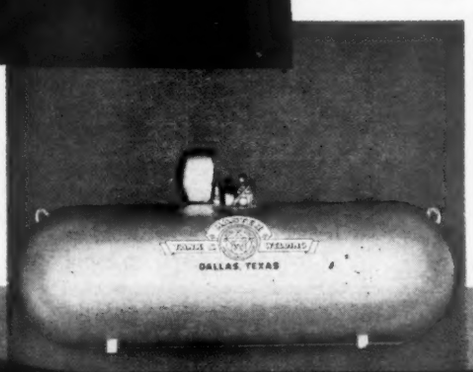
LPG and
Anhydrous
Ammonia
TRANSPORT
TANKS

API 5LX
EXPANDED LINEPIPE
20" - 30" Diameter



ANHYDROUS AMMONIA SYSTEMS

LPG
DOMESTIC
SYSTEMS



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Trade Literature

Publication will be sent free.

(S) SERVICING WINCH

New specification sheets for the Hyster D4N oil well servicing winch have been released by Hyster Company. The D4N winch is specifically designed for servicing shallow oil and gas wells. The winch drum has a capacity of 870 ft of ¾-in. line to 3480 ft of ⅜-in. line. A drum divider flange facilitates temporary line storage. Two output ranges, high speed or heavy duty, are obtained by changing gears in the field. All the controls can be operated easily from the ground. Spec sheets contain complete information, including conversion for seat tank and fender tank type tractors.

Circle letter (S) on reply card.

(T) HEAT PUMP

The new all-electric heat pump is described in a four-page bulletin available from the Westinghouse Electric Corporation. The heat pump is the completely self-contained system that—without water or flame—provides warm filtered air in the winter and cool, dehumidified air in the summer. A complete explanation of the heating and cooling cycles of the unit is presented in the bulletin.

Circle letter (T) on reply card.

(U) IRON, STEEL PRODUCTS

Kaiser Steel Corporation has announced publication of a new 340-page general catalog, which contains 117 pages of general technical information and reference tables, in addition to complete information on the company's iron and steel products. It is being distributed on a limited basis to Western architects, engineers, and manufacturers. Compiled and edited under the direction of B. J. Osborne, manager of engineering sales for the corporation, the catalog describes the characteristics, specifications, and practices for Kaiser's 16 product categories.

Circle letter (U) on reply card.

(V) AMMONIA PROCESS

Yield and cost advantages, principal operating features, and economics of a unique process design for ammonia plants are outlined in an 8-page booklet recently made available by The M. W. Kellogg Company. The present process includes a number of additional design innovations developed in the company's own semi-commercial plant. Among the features of the process is a reforming step which takes advantage of the high pressures at which natural gas is available. By conserving the potential energy of the feed and producing synthesis gas at relatively high pressure, savings in compressor horsepower are obtained.

Circle letter (V) on reply card.

(W) VAPOR BARRIER

Complete recommendations for vapor-sealing insulation on low temperature vessels are given in an 80-page, edition bound volume just published by the Insul-Mastic Corporation of America. The book is entitled "Vapor and Weather Barriers for Low Temperature Installations." It contains 54 illustrations showing exactly where and how a vaporseal coating should be applied over thermal insulation. Purpose of such a coating is to prevent deterioration of the insulation and rusting of the vessel beneath it due to moisture and moisture vapor.

Circle letter (W) on reply card.

(X) CALROD HEATERS

A 1954 edition of General Electric's catalog on Calrod electric heaters and heating devices has been announced as available from the company. Designated as GEC-1005E, the 60-page, 2-color catalog describes the units in terms of application, special features, installation, and pricing. More than 175 photographs and drawings illustrate the various products, including immersion, strip, cartridge, tubular, insertion, and fin heaters, melting pots, thermostats, switches, and oven heaters.

Circle letter (X) on reply card.

(Y) POWER SHOVELS

A 24-page, two-color bulletin has just been published by The Thew Shovel Company, which covers the crawler-mounted power shovels and cranes in the famous 1 yd Lorain "50" Series. Design and construction illustrations highlight the booklet. It explains very clearly the leading features of the "50" line, which include direct power from the engine through a center drive pinion to independently clutch-controlled hoist and swing-travel shafts, air controls for hoist, crowd, retract, and drag actions, the hydraulic coupling that prevents stalling and shock in shovel operations, etc.

Circle letter (Y) on reply card.

(Z) WELDING

"Welding With Ampco Bronze Electrodes-Filler Rod-Wire" is the title of the new 24-page Bulletin W-17 recently issued by Ampco Metal, Inc., describing the complete line of products for use with metal-arc, carbon-arc, inert-gas tungsten-arc, submerged-arc and inert-gas consumable electrode processes. Included in this bulletin are up-to-date technical information and data relative to welding with bronze electrodes and filler rods. Specific sections included cover Phos-Trode electrodes, Ampco-Trode electrodes and filler rods, welding techniques, etc.

Circle letter (Z) on reply card.

(AA) PUMPS

Quick, safe, efficient way of handling petroleum products is described in 10-page booklet listing complete line of the Gorman-Rupp Company. Booklet gives data on new "O" series pumps: Model GL-02 and O2-AEN, gear and engine driven units; Model 03B-B and 03C-B, electric motor driven, size 4 in. by 2 in.; Model 06B-B, electric motor driven, size 6 in. by 6 in.; Models 1103 and 12A-AKN, heavy duty pumps with pumping capacity in excess of 60 and 140 gpm, respectively. All are self-priming pumps for water, petroleum, and industrial liquids.

Circle letter (AA) on reply card.

(AB) PACKAGED DRYER

A new Hydryer bulletin has been published by J. F. Pritchard and Company's Hydryer section. The bulletin illustrates and describes the Hydryer and advantages and features. The Hydryer is a packaged dryer for reduction of moisture contents of compressed air or other gases to low dew points or concentrations. It reduces moisture content, thereby eliminating condensation of water and ice formation that cause control and operation difficulties or inefficiencies.

Circle letter (AB) on reply card.

(AC) LIFT TRUCK

Now available is a new eight-page illustrated catalog on the Hyster YT-40 lift truck. The YT-40 is a 4000-lb capacity model featuring trunnion-mounted steering and pneumatic tires. It is an all-purpose, inside-outside truck. Complete description, specifications, and actual on-the-job photos are included in the catalog.

Circle letter (AC) on reply card.

(AD) AUTOMATIC FILTERS

A new 12-page illustrated bulletin describing Staynew automatic filters designed for large air volume and high efficiency has been announced by the Dollinger Corporation. The bulletin contains specifications, engineering and performance data covering automatic filters in a wide range of sizes for handling any desired air capacity.

Circle letter (AD) on reply card.

(AE) CASING TONGS

Web Wilson Oil Tools, Inc., has published a leaflet on its Type "H" heavy duty rotary and casing tongs. The company reports that this type tong withstands, with safety, the extreme torques required to break the largest and tightest drill collars and tool joints. Such features as a short jaw that cannot be incorrectly assembled to the lever; ring retainers at both ends of the 2-in. hinge pins to prevent broken parts from falling out have been added to the new tongs.

Circle letter (AE) on reply card.

(AF) CALCULATOR

A new slide-chart calculator that quickly estimates pressure drop and indicates proper size steam valve needed for any pressures up to 1500 psi is now being distributed by Golden-Anderson Valve Specialty Company. Printed on this calculator are full operating instructions and necessary technical data.

Circle letter (AF) on reply card.

(AG) RECORDING CHARTS

A new illustrated catalogue covering thousands of recording charts is now available from the American Recording Chart Company. Charts for practically every leading make of recording instrument are listed within the 30-page catalog that is available upon request.

Circle letter (AG) on reply card.

(AH) HYDRA HOOK

Web Wilson Oil Tools, Inc., has published a leaflet on its new 125-ton Hydra Hook. It combines features of the Web Wilson connector hooks with such improvements as: Elimination of a top bearing, packed off body, to prevent oil leakage and keep the dash pot action at peak performance. It is 8 in. shorter and 1200 lb heavier than its predecessor.

Circle letter (AH) on reply card.